112136

CROSSLEY FARM

FOCUSED FEASIBILITY STUDY

EPA WORK ASSIGNMENT NO. 37-56-3LS2
PROJECT NO. 5081

ARCS III PROGRAM
CONTRACT NO. 68-W8-0037

JANUARY 1997

Halliburton NUS
CORPORATION

AR300179

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FOR THE
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

JANUARY 1997

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AR300180

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EXECUTIVE SUMMARY

This report presents the focused feasibility study (FFS) performed for the Crossley Farm National Priorities List Site, located in Hereford Township, Berks County, Pennsylvania. This FFS report was prepared by Halliburton NUS Corporation for the United States Environmental Protection Agency (EPA) under Work Assignment 37-56-3LS2, Contract No. 68-W8-0037.

This report was prepared consistent with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986; the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) 40 CFR 300; and the Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (EPA, October 1988).

The FFS report presents a range of remedial options that address potential human health risks that may result from the use of contaminated drinking water supplies that have been identified to date. These remedial alternatives are meant to provide a range of measures that would protect human health while a comprehensive remedial investigation is being conducted to assess the nature and extent of contaminant sources and affected groundwater, potential threats to human health, and impacts to the environment.

The remedial options developed in this document will be used by EPA to formulate a preferred remedy to address contaminated water supplies and to reduce or eliminate the health risks posed by exposure to chemicals. This preferred remedy will be presented to the community during a public meeting and through the news media and will be subject to a 60-day public comment period. After the public comment period has concluded, the selected remedy will be documented in an EPA Record of Decision (ROD). It is expected that the selected remedy for contaminated water supplies will be integrated into the eventual selected remedy for the entire site.

REMEDIAL ACTION OBJECTIVE

The results of a preliminary human health risk assessment (based on historical and current residential well and spring sampling results) conducted for this FFS and a comparison of contaminant levels from individual supplies to drinking water criteria indicate that groundwater posing unacceptable risks to human health exists in the vicinity of the Crossley Farm Site. Consequently, one remedial action objective was identified to address contaminated private water supplies in the vicinity of the Crossley Farm Site.

Because of the continued exposure of residents to groundwater contaminants associated with the Crossley Farm Site, the remedial action objective for the protection of human health is to

- Prevent human exposures to contaminated water supplies that exceed drinking water criteria [Maximum Contaminant Levels (MCLs)] or result in excess cumulative carcinogenic health risks (greater than 1E-4) and noncarcinogenic health risks (Hazard Indices greater than 1.0).

REMEDIAL ALTERNATIVES DEVELOPMENT

A set of proposed preliminary remediation goals was compiled to address the proposed remedial action objective. Preliminary remediation goals (PRGs) are numerical concentration values for contaminants present in the groundwater that would be protective of human health if that water were used for drinking water supplies. Based on the results of the preliminary risk assessment and the site-specific contaminants of concern, a set of proposed PRGs was assembled based on federal and state primary drinking water criteria and risk-based values developed by EPA Region III. These numerical values were considered to assess whether various remedial technologies would be effective in preventing, reducing, or mitigating potential exposures to site-related chemical contaminants.

The federal drinking water criteria are Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act. MCLs specify the maximum permissible levels of contaminants in finished water produced by public water supplies delivered to the public. The MCLs are numerical limits for selected contaminants such that their presence in drinking water supplies does not pose adverse effects to users. MCLs have also been promulgated by the commonwealth of Pennsylvania. Although MCLs are not used to regulate the quality of water produced by private water supplies, the numerical limits specified under these regulations can be used to establish PRGs that would be protective of human health for use of groundwater in the study area. Table 2-4 presents the contaminants of concern identified in the study area and the corresponding federal and state MCLs.

Risk-based concentrations (RBCs) are concentration values for nearly 600 chemicals that have been developed by EPA Region III and that correspond to fixed levels of risks (lifetime carcinogenic risk of 1E-6 or a Hazard Quotient of 1.0 for non-carcinogenic risk). The EPA Region III RBCs developed for the use of tap water for the contaminants of concern at this site are presented in Table 2-4.

The proposed PRGs for this FFS are presented in Table 2-5. The federal MCLs were typically selected as the preliminary remediation goals, unless there were more stringent state MCLs. If MCLs were unavailable, then the EPA Region III RBCs were selected.

Following the screening and detailed evaluation of the various technologies versus the criteria discussed above, the remedial technologies were assembled into five alternatives that addressed contaminated private residential water supplies. These five alternatives provide variable levels of protection to human health and compliance with applicable or relevant and approriate requirements (ARARs). The five remedial alternatives are no action, delivered water, point-of-entry treatment, new supply well and treatment, and a water line. The new supply well alternative was determined to be not technically implementable at this stage of site activities (the remedial investigation has not been completed), and was not evaluated in detail. The four remaining remedial alternatives are discussed below.

ALTERNATE WATER SUPPLY OPTIONS

To achieve the remedial action objective, the remedial alternatives developed for this FFS must prevent residents from being exposed to site-specific contaminants in excess of drinking water criteria, reduce total carcinogenic risks to within or below the acceptable risk range (1E-4 to 1E-6), and reduce noncarcinogenic risks such that the Hazard Indices are below 1.0.

Alternative 1: No Action

The no-action alternative was developed, as required by the NCP, as a baseline to which other alternatives may be compared. Periodic reviews of site conditions, typically every 5 years, and long-term groundwater monitoring would be the only activities conducted under this alternative.

Alternative 2: Delivered Water

Under this alternative, bottled or bulk water would be provided to each residence that has a water supply contaminated in excess of the federal or state primary drinking water criteria (MCLs) or risk-based levels. Provision of delivered water would reduce or eliminate further exposures (through drinking, inhalation, or dermal contact) to volatile organic compound (VOC) and metal contaminants in the groundwater. The water would be delivered regularly.

Institutional controls such as ordinances or deed restrictions might be enacted to prohibit the use of contaminated groundwater for drinking water. Existing residential supply wells and selected monitoring wells would be incorporated into a long-term monitoring network. Groundwater would be monitored annually for VOCs and metals to assess the contaminant plume status and to assess whether additional homes may be at risk from contaminated water supplies. Because contaminants remain in the underlying aquifer and would continue to pose threats to groundwater users, 5-year reviews would be conducted to assess site conditions and whether additional response actions would be necessary.

Two scenarios are viable under Alternative 2:

- Alternative 2A - All 29 currently affected residents would be provided with new storage tanks and delivered bulk water.

- Alternative 2B - The five homes with either an individual or cumulative risk for dermal contact and inhalation of greater than 1E-4 or an individual or cumulative Hazard Quotient greater than 1.0 for dermal contact and inhalation would be provided with bulk water to prevent contact with contaminants through these pathways, and the remaining 24 affected homes would be provided with bottled water to prevent ingestion of water in excess of MCLs.

Alternative 3: Point-of-Entry Treatment

This alternative calls for the use of point-of-entry treatment units to treat the extracted groundwater at each affected residence. Under this alternative, all 29 currently affected residents would be provided with point-of-entry treatment units. Water pumped from the private wells would be passed through the treatment systems at the point of entry into the homes. Each typical treatment system would be composed of a prefilter to remove suspended solids, dual in-series activated-carbon units to remove VOCs, and an ultraviolet (UV) radiation unit to provide disinfection. Depending on the contaminants identified at specific residences, additional treatment components may be required, such as pH adjustment or a water-softening unit to remove manganese and iron. The activated carbon would be replaced on a periodic basis or when breakthrough is identified. Through the provision of these treatment systems, contaminant concentrations would be reduced to below the drinking water criteria (MCLs).

Institutional controls such as ordinances or deed restrictions may be enacted to prohibit the use of contaminated groundwater for drinking water use, if treatment is not employed. Existing residential supply wells and selected monitoring wells would be incorporated into a long-term monitoring network to determine whether the water supplies of other residences may be affected and the status of groundwater contamination. Groundwater would be monitored annually for VOCs and metals. Because contaminants remain in the aquifer and would continue to pose threats to groundwater users, 5-year reviews would be conducted to assess site conditions and whether additional response actions are necessary.

Alternative 4: Water Line

Under this alternative, the existing water distribution main from the nearby borough of Bally would be extended throughout Hereford and Washington Townships so that service lines could be provided to the 29 affected residences. The extension would require excavations in or along public roadways, installation of the underground piping for the distribution main, installation of service lines to the property lines of affected residences, and connection of the service lines to the plumbing system within each household. Four booster pumping stations would be established to provide sufficient hydraulic head in the water supply in this area of very steep terrain. While the water line extension is being constructed, residences with contaminated groundwater in excess of drinking water criteria (MCLs) or risk-based action levels would be provided temporarily with an alternate water supply (either bottled water or point-of-entry treatment systems).

According to the Bally Municipal Water Department manager, the borough of Bally currently uses one of two supply wells to provide potable water to residential, commercial, and industrial customers. The water department is interested in expanding its service and providing potable water to other customers. Bally obtains its water supply from the bedrock aquifer underlying the borough. This aquifer appears to have been contaminated as the result of separate disposal activities; Bally treats the water to drinking water quality and sends the finished water into its distribution system.

Coordination among EPA, the Pennsylvania Department of Environmental Protection (PADEP), the borough of Bally, and Hereford and Washington Townships would be required for the construction of the water line extension and for administration and management of the extended water supply service. It is presumed that the administration, management, and long-term operation and maintenance of the supply well and treatment would remain the responsibility of the borough of Bally.

Institutional controls such as ordinances or deed restrictions may be employed to prohibit the use of contaminated groundwater for drinking water, if treatment is not employed. Existing residential supply wells and selected monitoring wells would be incorporated into a long-term monitoring network to determine whether the water supplies of other residences may be affected and the status of groundwater contamination. Groundwater would be monitored annually for VOCs and metals. Because contaminants would remain in the aquifer and would continue to pose threats to groundwater users, 5-year reviews would be conducted to assess the status of site conditions and to review risks.

Institutional controls would be required to prevent the installation of new private wells that do not include treatment or to prevent the use of untreated groundwater from existing wells.

ALTERNATIVES SCREENING

The screening summary for the proposed alternatives is presented in Table 3-1. Alternatives were not evaluated against each well exhibiting a risk. Rather, each alternative was evaluated versus its effectiveness at meeting the remedial action objective and in reducing risks posed to residents using contaminated groundwater.

Because of the uncertainties associated with the current status of the contaminated groundwater plume, Alternative 5 (new supply well with treatment) was eliminated from further consideration. The nature and extent of the groundwater contaminant plume, how the contaminants are migrating, and the pathways of contaminant migration are being addressed by the ongoing remedial investigation. It is possible that the installation of a high-capacity supply well under Alternative 5 could result in inadvertent changes to contaminant flow patterns and the capture of contaminants by the supply well. The well installation could also exacerbate the existing groundwater problem before a remedy can be implemented. If contaminated groundwater of unknown concentrations and distribution is used for a water supply, the design of the treatment system will need to accommodate a variety of operating conditions. Given all these uncertainties, it is impractical to design an effective water treatment system without much more information. Therefore, Alternative 5 is not considered to be technically implementable.

Each of the remaining four alternatives passing the screening process will be evaluated in detail in this FFS.

INDIVIDUAL AND COMPARATIVE ANALYSIS OF ALTERNATIVES

Detailed evaluations of the alternate water supplies options were performed for this FFS in accordance with the requirements of CERCLA, the National Contingency Plan, and the EPA Remedial Investigation/Feasibility Study (RI/FS) Guidance Document. As part of the detailed analysis, the remedial alternatives were compared to identify differences and to compare how site contaminant threats are addressed.

The following seven criteria, as established by the NCP, were used for the detailed analysis of alternatives:

- Overall protection of human health and the environment
- Compliance with Applicable or relevant and appropriate requirements (ARARs)
- Long-term effectiveness and permanence
- Reduction of mobility, toxicity, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost

Two other evaluation criteria, state and community acceptance, will be addressed in the Record of Decision following the receipt of comments during the public comment period, after EPA's Proposed Plan has been presented to the public.

The key components of remedial alternative 2 (delivered water), alternative 3 (point-of-entry treatment) and alternative 4 (water line) relative to the seven evaluation criteria are summarized below. The detailed evaluations of the remedial alternatives are presented in Section 4.1. Detailed summaries and a comparative analysis of the remedial alternatives are presented in Table 5-1.

Overall Protection of Human Health and the Environment

Alternatives 2, 3, and 4 would all prevent exposure to groundwater that is contaminated in excess of drinking water or risk-based limits. Alternative 2 is not a permanent measure. The reliability of Alternative 3 to prevent exposure depends on the proper operation and maintenance of the treatment system. Alternative 4 would be reliable because the water would be supplied by a municipal water authority.

Compliance with ARARs

Alternatives 2, 3, and 4 would comply with chemical-, location-, and action-specific ARARs. However, Alternatives 2 and 3 would rely on the user (to varying degrees) for control and compliance. Alternative 4 would comply with ARARs since the water would be supplied by a municipal water authority.

Long-Term Effectiveness and Permanence

Alternatives 2, 3, and 4 would all reduce carcinogenic and noncarcinogenic risks to below or within the acceptable risk range for the long term. However, Alternative 2 is only an interim measure. Also, increases in the levels of groundwater contaminants could potentially expose the drinkers of bottled water to unacceptable risks through the dermal contact or inhalation exposure pathways. Alternative 3 would be effective and reliable if the treatment system is properly operated and maintained. However, if contaminant concentrations in the groundwater increase, then the treatment systems may need to be upgraded to offer the same degree of protection. Alternative 4 would be a permanent remedial measure and is considered superior to Alternatives 2 and 3 because increases in groundwater contaminant concentrations would not affect the protection afforded by the new supply line.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 2 would not treat the groundwater and would not reduce the toxicity, mobility, or volume of contaminated groundwater. Alternative 3 would treat an estimated 125 gallons of groundwater per person per day. The VOCs captured by the treatment would be disposed off site. Alternative 4 would indirectly treat an estimated 300,000 gallons of groundwater per day by the Bally Municipal Water Department but not water from the aquifer beneath the Crossley Farm Site. The contaminated groundwater that would be treated is associated with another NPL site in Bally Borough. The VOCs captured through this treatment would be vented to ambient air.

Short-Term Effectiveness

Alternative 2 can be completed within approximately 6 months. Alternative 2 is reliable, and no difficulties are expected through the construction and operation of the systems. Additional actions can be readily implemented if required after the 5-year review. Long-term monitoring would identify any additional homes with contaminated water supplies; bottled water could rapidly be provided to these homes on short notice.

Alternative 3 can be completed within approximately 6 months. Alternative 3 would be slightly more difficult to construct than Alternative 2 and would require water deliveries in the near term until all the treatment units are installed. Additional actions can be readily implemented if required after the 5-year review. Long-term monitoring would identify any additional homes with contaminated water supplies. Point-of-entry treatment systems could be installed in these homes. However, bottled water would need to be provided until the systems were installed.

Alternative 4 can be completed within 2 to 4 years. Alternative 4 would be the most difficult to construct. Extensive excavations and construction would be required. In addition, considerable lead time would be needed for ordering and purchasing pumps and piping. Additional actions can be readily implemented if required after the 5-year review. Long-term monitoring would identify any additional homes with contaminated water supplies. These homes could be readily connected to the public water line, since the main distribution network would already be established. However, bottled water would need to be provided until the connections were made.

Implementability

The technologies and equipment needed for the implementation of Alternatives 2, 3, and 4 are readily available. The deed restrictions associated with each alternative may be difficult to implement. For Alternative 2, coordination among agencies may be required for the delivery of water. For Alternative 3, coordination among agencies may be required for the installation and service of the treatment systems. For Alternative 4, coordination among various agencies and local municipalities would be required for the administration of the water distribution system, including the maintenance of the water lines and pump, the collection of fees, and service.

Cost

The costs for each alternative are summarized in the following table. For each alternative, $23,000 should be added to the annual operations and maintenance (O&M) every 5 years for reviews.

Cost Criteria	Alternative 1: No Action	Alternative 2: Delivered Water	Alternative 3: Point-of-Entry Treatment	Alternative 4: Water Line
Capital Cost	$0	Alt. 2A: $120,420 Alt. 2B: $22,270	$172,230	$7,324,000 (branched) $9,887,000 (looped)
Annual O&M	$44,120	Alt. 2A: $314,440 Alt. 2B: $140,200	$117,240	$117,240 (years 1-4) $102,740 (year 5) $88,240 (years 6-30)
Present-Worth Cost	$597,117	Alt. 2A: $4,071,951 Alt. 2B: $1,811,645	$1,676,700	$8,566,383 (branched) $11,140,151 (looped)

Note: Alternative 5 (new supply well) did not pass the screening criterion of technical implementability. No cost estimate for this alternative was prepared.

1

1.0 INTRODUCTION

1.1 PURPOSE OF THE REPORT

This report presents the focused feasibility study (FFS) performed for the Crossley Farm National Priorities List Site, located in Hereford Township, Berks County, Pennsylvania. This FFS report was prepared by Halliburton NUS Corporation (HNUS) for the United States Environmental Protection Agency (EPA) under Work Assignment 37-56-3LS2, Contract No. 68-W8-0037. The FFS report presents a range of remedial alternatives that address potential human health risks that may result from the use of contaminated drinking water supplies that have been identified to date. These remedial alternatives are meant to provide a range of remedial measures that would protect human health while a comprehensive remedial investigation is being conducted to assess the nature and extent of contaminant sources and affected groundwater, potential threats to human health, and impacts to the environment.

This FFS was prepared consistent with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986; the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) 40 CFR 300; and the Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (EPA, October 1988).

The remedial options developed in this document will be used by EPA to formulate a preferred remedy to address contaminated water supplies and to reduce or eliminate the health risks posed by exposure to chemicals. This preferred remedy will be presented to the community during a public meeting and through the news media and will be subject to a 60-day public comment period. After the public comment period has concluded, the selected remedy will be documented in an EPA Record of Decision (ROD). It is expected that the selected remedy for contaminated water supplies would be integrated into the eventual selected remedy for the entire site.

1.2 BACKGROUND INFORMATION

1.2.1 Site Description and Setting

The Crossley Farm Site is located in the Huffs Church community of Hereford Township, Berks County, Pennsylvania. This location is approximately 50 miles northwest of Philadelphia and 21 miles northeast of Reading (Figure 1-1). The site is located along the southern side of Huffs Church Road, approximately 3 miles west-northwest of State Route 100 and northwest of the borough of Bally (Figure 1-2).

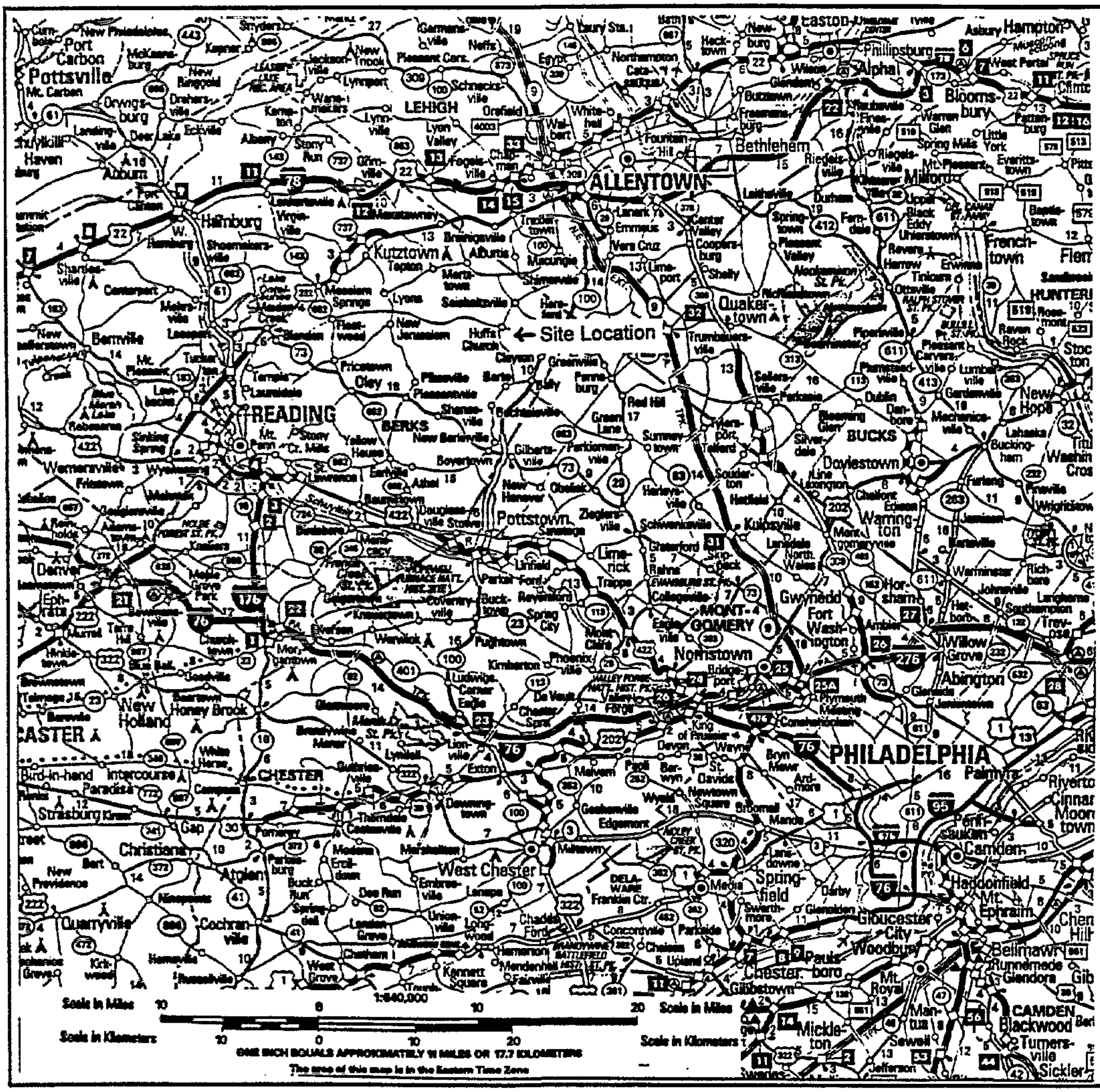

FIGURE 1-1

SITE LOCATION MAP
CROSSLEY FARM RI/FS
HEREFORD TOWNSHIP, BERKS COUNTY, PA

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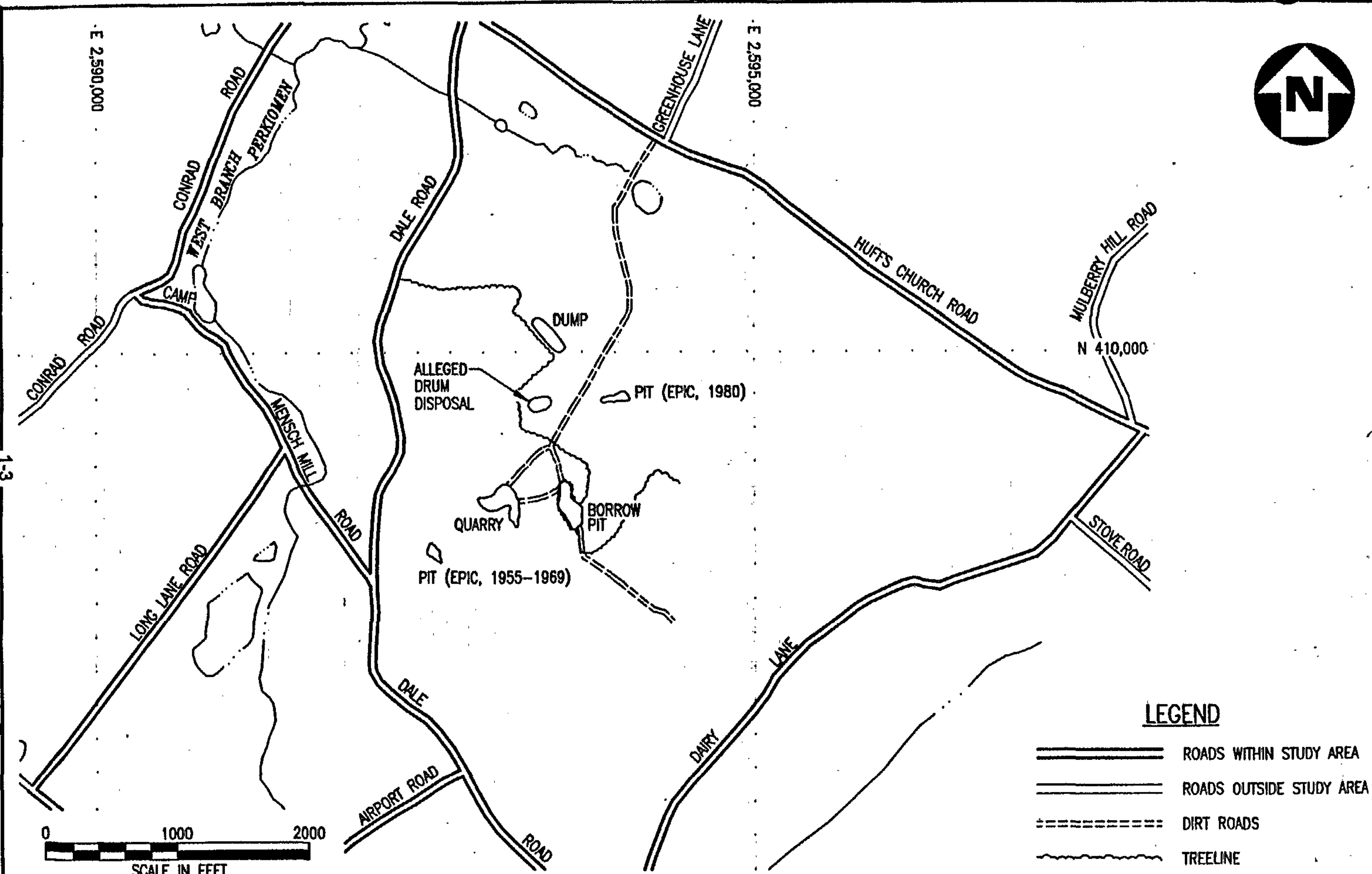

GENERAL SITE FEATURES, CROSSLEY FARM RI/FS
HEREFORD TOWNSHIP, BERKS COUNTY, PA.

FIGURE 1-2

Halliburton NUS CORPORATION

SOURCE:
PROPERTY MAP OF BERKS COUNTY, PENNSYLVANIA, MAP NUMBERS 5841 04, 5491 03, 5491 04, 5480 02, 5490 01, 5490 02, 5480 04, 5490 03, 5490 04, 5389 02, 5399 01, 5399 02, 5389 04, 5399 03 AND 5399 04, SEPTEMBER 7, 1994; UNITED STATES GEOLOGICAL SURVEY, EAST GREENVILLE, PENNSYLVANIA QUADRANGLE, 7.5 MINUTE SERIES. TOPOGRAPHIC MAP. 1956, PHOTOREVISED 1969 AND 1973, PHOTO INSPECTED 1980; AND UNITED STATES GEOLOGICAL SURVEY, MANATANNEY, PENNSYLVANIA QUADRANGLE, 7.5 MINUTE SERIES. TOPOGRAPHIC MAP. 1957, PHOTOREVISED 1969 AND 1973.

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The site is located within the Reading Prong Physiographic Province. The topography within the study area primarily reflects the complex underlying bedrock geology and consists of high hills and ridges underlain by more resistant metamorphic and igneous rocks and broad, low valleys underlain by less resistant carbonate rocks. The most prominent highland within the study area occurs at the site and is known locally as Blackhead Hill. The hill is very steeply sloped to the west and south of its crest. To the north and east of its crest, the hill is fairly level or flat and supports a working farm over much of its area. The crest of Blackhead Hill is underlain by the Hardyston Quartzite, which makes an attractive building stone. A small quarry at the crest of the hill has been active for over 50 years.

1.2.2 Site Operating History

The Crossley Farm is an active farm that has operated as a dairy farm and a crop farm. Some dairy farming still occurs, although the dairy operations were reportedly more extensive in the past; the dates of operation are uncertain. Presently, most of the farm is dedicated to crops; corn is the dominant crop.

The quarry at the crest of Blackhead Hill has been mined for building stone since at least 1946 (the date of the earliest aerial photograph available for the site). The presence of Hardyston Quartzite as building stone in older, local structures suggests that the quarry may have existed well before the 1940s. Site records indicate that a local building stone company routinely obtained stone from the quarry from 1957 to at least the late 1970s.

From the mid-1960s to the mid-1970s, a local plant reportedly sent numerous drums to the Crossley Farm for disposal. These drums contained mostly liquid waste and were described as having a distinctive "solvent" odor. The plant was believed to have used trichloroethene (TCE) as a degreaser from at least the mid-1960s until 1973 and tetracholorethene (PCE) from at least the early 1960s until 1980.

Known and alleged waste disposal areas include a household dump, the quarry, and a borrow pit area. The dump is located approximately 2,000 feet south of Huffs Church Road and reportedly consists chiefly of household trash. The quarry is located approximately 3,000 feet south of Huffs Church Road and is allegedly a former site of unregulated disposal of hazardous waste, chiefly chlorinated solvents. The borrow area is located approximately 400 feet east of the quarry and is allegedly a former unregulated staging and/or disposal area of hazardous wastes, chiefly chlorinated solvents. All of these suspected source areas are being investigated by the ongoing remedial investigation.

1.2.3 Regulatory History

Regulatory involvement at this site began in 1983, when local residents complained to the Pennsylvania Department of Environmental Protection (PADEP) about odors in private water supply wells. A PADEP sampling program of local wells conducted in September 1983 revealed concentrations of TCE as high as 8,500 ug/L and PCE as high as 110 ug/L. A subsequent sampling round conducted by PADEP and the EPA Region III Technical Assistance Team (TAT) contractor in November 1983 revealed that eight home wells contained detectable levels of TCE, and in six of these wells the concentrations of TCE exceeded 200 ug/L.

As a result of the November 1983 sampling, PADEP issued a health advisory on groundwater use in the area and recommended either boiling water, installing carbon filtration systems, or using bottled water where TCE concentrations exceeded 45 ug/L. Shortly thereafter, a temporary water supply was provided by the Pennsylvania National Guard through the Pennsylvania Emergency Management Agency. This supply was terminated in mid-1985.

After the health advisory was issued, local residents began to voice concerns about Crossley Farm and alleged dumping of wastes there. In response to these concerns, EPA directed the Region III Field Investigation Team (FIT) contractor to conduct a preliminary assessment (PA) of the property. The PA, completed in June 1984, concluded that insufficient information existed to identify the source of the groundwater contamination and suggested that a regional groundwater study be conducted.

Further citizen complaints in August 1986 prompted additional rounds of sampling by the TAT contractor in September 1986. TCE levels detected during these rounds ranged up to 19,000 ug/L. In October 1986, the Agency for Toxic Substances and Disease Registry (ATSDR) performed a health consultation for EPA. Additional well sampling in November 1986 detected TCE at a maximum level of 22,857 ug/L. EPA initiated a removal action in December 1986 and, in January 1987, EPA began installing carbon filtration units on impacted private wells.

In the spring of 1987, EPA directed the Region III Emergency Response Team (ERT) contractor to conduct a regional hydrogeological investigation to include the installation and sampling of on- and off-site monitoring wells and the sampling of residential well supplies. This investigation, completed in August 1988, concluded that the source of the TCE in the groundwater was near the crest of Blackhead Hill. The abandoned quarry and the borrow pit area were cited as the presumed source areas. The investigation delineated a contaminated groundwater plume extending approximately 7,000 feet downgradient from Blackhead Hill and along Dale Road.

Concurrent with and independent of the EPA study, residential wells near Dale were sampled and analyzed for polychlorinated biphenyls (PCBs) and other contaminants as part of a PADEP investigation of the Texas Eastern - Bechtelsville compressor station. One residential well located on Forgedale Road contained TCE at levels greater than 200 ug/L, suggesting that the TCE plume associated with the

Crossley Farm Site extended even farther to the south than mapped, since TCE was determined not to be a common waste product from compressor station operations. This result prompted additional sampling by EPA along Forgedale Road, south to Old Route 100, as part of the Crossley Farm investigation. These analytical data indicated that the plume extended south of the compressor station and Forgedale Road and about 9,000 feet downgradient from Blackhead Hill.

In February 1991, EPA issued the final Hazard Ranking System (HRS) package for the Crossley Farm Site in preparation for the site's proposal for the National Priorities List (NPL). In July 1991, the site was proposed for the NPL. The site was formally listed on the NPL in October 1992.

In September 1991, ATSDR performed a health consultation of the Crossley Farm Site at the request of the Pennsylvania Department of Health (PADOH). ATSDR recommended that the extent of the contaminated groundwater plume be defined and that all supply wells that could potentially be affected by the contamination be identified and monitored.

In March 1992, PADOH and ATSDR held a community meeting to meet with interested or concerned residents. ATSDR representatives discussed the National Exposure Registry and the process of bringing exposed individuals into the TCE Subregistry. In the days following the meeting, some area residents believed to have been exposed to the highest levels of TCE in the groundwater were added to the registry. PADOH and ATSDR also conducted a presentation to the Berks County Medical Society on the TCE contamination of environmental media at several NPL sites in Berks County and the toxic effects of TCE on humans.

In February 1993, ATSDR finalized a preliminary public health assessment for the Crossley Farm Site. The assessment concluded that the site presented an urgent public health hazard and made recommendations to reduce the public health risk associated with the site.

In July 1994, ATSDR issued a Site Review and Update (SRU) for the Crossley Farm Site. The SRU stated that the site remained a public health hazard to area residents and recommended that either a health consult or another SRU be performed upon completion of a planned remedial investigation for the site.

In September 1994, EPA tasked Halliburton NUS Corporation to perform a remedial investigation and feasibility study (RI/FS) for the site. It was decided during subsequent scoping meetings and discussions that the investigation and ultimate disposition of the contaminated residential well supply problem should be expedited and addressed in a focused feasibility study (FFS) prior to the site investigation activities.

1.2.4 EPA Removal Action

EPA initiated a removal action in December 1986 by installing carbon filter units on the most severely impacted residential wells. A contaminant concentration level of 180 ug/L of TCE or greater was used as the criterion for the removal action for any particular well. This criterion was developed in consultation with ATSDR and was based on one-half of the Drinking Water Equivalent Level (DWEL).

A total of 15 carbon filter units have been installed and are maintained by EPA. A contractor services the units approximately every 2 months, and the carbon units are rotated about every 6 months.

1.3 NATURE AND EXTENT OF CONTAMINATION

The full nature and extent of contamination in all media associated with the disposal of hazardous wastes on the Crossley Farm Site are unknown at this time and will be delineated by the remedial investigation. At present, significant data exist regarding the nature and lateral extent of on-site and off-site volatile organic compounds in groundwater, and limited data exist regarding the nature of off-site semivolatile and inorganic compounds in groundwater.

1.3.1 Volatile Organic Compounds

Volatile organic compounds (VOCs) have been detected at significant levels in groundwater through the multiple sampling of 21 monitoring wells and numerous home wells. During the last sampling round (November/December 1995), nearly all potable wells and springs within the study area (a total of 104 different groundwater sources) were sampled for VOCs to support this FFS and to gather data to aid in the scoping of the remedial investigation (Figure 1-3, in pocket). Permission to sample was denied at some residences, and sampling arrangements could not be arranged at a few others.

The analytical results from all sampling rounds indicate that a large plume of contaminated groundwater originates near the crest of Blackhead Hill and is migrating southward and downgradient approximately 9,000 feet into the Dale Valley. The principal chemical components of this plume are the VOCs TCE and PCE, though a few other compounds also appear but much less consistently and at lower concentrations. Neither the precise source location(s) nor the vertical distribution or extent of the contamination is known at this time. These data gaps will be investigated during the remedial investigation.

1.3.2 Semivolatile Organic Compounds

Limited data exist concerning the nature and extent of semivolatile organic compounds (SVOCs) at the site. A total of 14 residential wells were analyzed during the September 1995 and/or the

November/December 1995 sampling round for these compounds. No other wells or media have been analyzed for SVOCs. This data gap will be investigated during the remedial investigation.

The limited data suggest that the off-site groundwater is not significantly impacted by SVOCs. The wells selected for analysis are either located closest to the site or historically have had the highest levels of VOCs in their groundwater. Therefore, they would be considered the wells most likely to contain SVOCs. The analyses, however, indicate that the distribution of SVOCs is irregular and their concentrations are very low (equal to or less than 1 ug/L). Di-n-butylphthalate, a plasticizer and common laboratory contaminant, was the only compound to occur in more than one sample; the maximum concentration of this compound was 1 ug/L.

Tris(2-chloroethyl)phosphate, a flame-retardant plasticizer, was detected in three wells as a tentatively identified compound (TIC). The occurrence of this compound will be further investigated during the remedial investigation.

1.3.3 Inorganic Compounds

Limited data exist concerning the nature and extent of metals at the site. A total of 14 residential wells were analyzed for metals during the September 1995 and/or the November/December 1995 sampling round. No other wells or media have been analyzed for metals. This data gap will be investigated during the remedial investigation.

The limited data suggest that off-site groundwater may be impacted by metals. Based on their concentrations relative to EPA Region III screening levels, the metals cadmium, copper, iron, and manganese were all selected as chemicals of concern during the preliminary risk assessment conducted for this FFS. In addition, the concentration of lead in at least one well exceeded the state MCL of 5 ug/L. The concentrations of these metals in the monitoring wells are not known at this time. It is also not known what the naturally occurring background levels of these metals may be or to what extent plumbing may be contributing to the concentration levels of some of the metals (principally lead and copper) through the leaching of these metals from the pipes by acidic groundwater. These data gaps will be investigated during the remedial investigation.

1.4 PRELIMINARY RISK ASSESSMENT SUMMARY

A preliminary risk assessment (PRA) was completed by HNUS in October 1996 to assess the potential risks to human health that could result from using contaminated groundwater underlying the site area. The PRA was developed using analytical results from the historical sampling of residential wells (VOCs, only) and from the September, November, and December 1995 sampling round (VOCs, SVOCs, and inorganic compounds). The PRA reviewed and screened the analytical results from all the wells and springs within the study area for which data are available, a total of 136 different groundwater sources. These results were used to identify contaminants of concern, potential exposure pathways that result in unacceptable risks to residents living near the Crossley Farm Site, and residences that may be subjected to potential health risks from using groundwater affected by site contaminants.

As part of the PRA, the EPA Region III risk-based concentration screening method (EPA III, October 1995) was applied to identify a set of contaminants of concern (COCs) for each sampled well. The screening retained chemicals for further evaluation if the maximum detected concentration, when compared to risk-based screening levels, exceeded a lifetime carcinogenic risk of 1E-6 or a systemic Hazard Quotient of 0.1 for noncarcinogens. Chemicals eliminated from further consideration under the screening process were assumed to present minimal risks to potential users of groundwater. All wells containing chemicals at concentrations above the COC screening levels were retained for further risk evaluation. A total of 38 wells and two springs passed the screening threshold and were retained for further evaluation. It was later determined that one of the springs does not represent a potable source; this spring was not considered in this FFS.

The PRA used the maximum detected concentrations for each well under the Reasonable Maximum Exposure (RME) scenarios to characterize the risks. These conditions represent a conservative approach and may not be representative of actual or typical conditions. Exposure scenarios for adults and children were developed for ingestion, dermal contact, and inhalation of contaminants through use of groundwater obtained from the residential wells.

The results of the risk characterization (cumulative risks for ingestion, dermal contact, and inhalation) are presented in Table 1.5-F of the preliminary risk assessment, which is also included in Appendix A of this document.

1.4.1 Contaminants of Concern

Carcinogenic risks are calculated according to risk assessment methods outlined in current EPA guidance. Lifetime cancer risks are represented by unitless values and are expressions of an individual's likelihood of developing cancer from exposure to carcinogenic chemicals. An incremental cancer risk of 1E-6, for example, indicates that the exposed receptor has a one-in-one-million chance of developing cancer under the defined exposure scenario. Alternatively, such a risk may be interpreted as representing one additional case of cancer in an exposed population of one million persons. The preliminary risk assessment determined that TCE is the major contributor of excess carcinogenic risk for most wells. Other COCs that individually contribute carcinogenic risk in excess of 1E-6 include PCE, chloromethane, methylene chloride, bromodichloromethane, chloroform, carbon tetrachloride, and 1,1-dichloroethene (1,1-DCE).

Noncarcinogenic risks are assessed using the concept of Hazard Quotients (HQs) and Hazard Indices (HIs). HQs are calculated for for individual COCs. An HI is generated by summing the individual HQs for the COCs. If the value of the HI exceeds unity (1.0), there is a potential noncarcinogenic health risk associated with exposure to that chemical mixture. The HI is not a mathematical prediction of the severity of toxic effects and therefore not a true "risk"; it is simply a numerical indicator of the possibility of the occurrence of noncarcinogenic (threshold) effects. The preliminary risk assessment identified TCE as the major contributor to noncarcinogenic risk, with an individual HQ exceeding 1.0. Manganese, PCE, and cis-1,2-dichloroethene have HQs exceeding 1.0 for the child receptor, and trichlorofluoromethane has an HQ exceeding 1.0 for the adult receptor.

The carcinogenic and noncarcinogenic risks posed by TCE and other COCs in private drinking water supplies were considered during the alternatives development under this FFS.

1.4.2 Exposure Pathways

Ingestion of groundwater was the pathway that resulted in greatest carcinogenic risk, followed by inhalation and dermal contact. Ingestion and inhalation carcinogenic risks were generally of the same order of magnitude, but ingestion risks were numerically higher (at least five times) than inhalation risks. Dermal contact risks were about one order of magnitude less than either ingestion or inhalation exposure risks.

Ingestion of contaminated groundwater was the major contributor of non-carcinogenic risks. Non-carcinogenic risks through dermal contact were generally below a Hazard Index (HI) of 1.0, with the exception of wells W-19, W-20, W-22, and W-29; this exposure route was deemed not to pose substantial risks. The HIs for inhalation of VOCs from the use of potable water were below an HI of 1.0 for all adult and child residents; therefore, this exposure pathway appears to pose only minimal non-carcinogenic health risks. For well W-99, the HIs for the dermal and inhalation routes were individually below 1.0, but the cumulative HI for these exposure routes was greater than 1.0.

1.5 ORGANIZATION OF REPORT

The FFS is presented in one volume. Section 1.0 presents the purpose of the FFS report, a description of the site, the site's history, a discussion of the nature and extent of contamination, and results of the preliminary human health risk assessment. Section 2.0 presents the ARARs, the remedial action objective, the general response actions, preliminary remediation goals, and the identification and screening of alternatives. Section 3.0 presents the development and detailed descriptions of remedial action alternatives. Section 4.0 presents detailed analysis of remedial action alternatives, and Section 5.0 presents a comparative analysis of the alternatives.

2

2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

Remedial alternatives are developed by assembling combinations of technologies and the media to which they would be applied into an appropriate range of alternatives that address site contamination or problems. This section presents the preliminary phase of the remedial alternatives development process. The process consists of the following steps:

- Develop remedial action objectives (RAOs) that are protective of human health and specify the contaminants and media of concern, exposure pathways, and preliminary remediation goals (PRGs) that permit a range of treatment and containment alternatives to be developed.
- Develop general response actions for each medium of interest that define measures that may be taken singly or in combination to satisfy the RAOs for the site.
- Identify the numbers, volumes, or areas of media to which the general response actions might be applied.
- Identify and screen the technologies applicable to each general response action.

Section 2.1 presents a preliminary listing of applicable or relevant and appropriate requirements (ARARs) and other guidance to be considered in the development of RAOs for the Crossley Farm Site. Section 2.2 presents the protection of human health RAO. Section 2.3 presents the preliminary remediation goals. Section 2.4 identifies the general response actions that may be implemented at the site, and Section 2.5 presents the screening of technologies and process options.

2.1 ARARS AND TBCS

ARARs are promulgated, enforceable federal and state, environmental, or public health requirements that are determined to be legally applicable or relevant and appropriate to the hazardous substances, remedial actions, or other circumstances at a CERCLA site. The NCP Section 300.430 states that on-site remedial actions at CERCLA sites must meet ARARs unless there are grounds for invoking a waiver. A waiver is required if ARARs cannot be achieved. The two classes of ARARs, "applicable" and "relevant and appropriate" requirements, are defined below.

Applicable Requirements - Section 300.5 of the NCP defines applicable requirements as "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site." For example, if a new municipal well is established in the study area, then the quality of finished water produced by a public water supply would have to conform with the Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs), which are requirements specifically applicable to the activities performed by the public water supply.

Relevant and Appropriate Requirements - Section 300.5 of the NCP defines relevant and appropriate requirements as "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at a CERCLA site that their use is well suited to the particular site." For example, a private residence is equipped with a point-of-entry water treatment system. While there are no "applicable" requirements governing the quality of water produced by the point-of-entry treatment system, it would be possible to specify the SDWA MCLs as "relevant and appropriate" requirements to identify treatment goals for the quality of water produced by the system.

TBCs (standards and guidance to be considered) are non-promulgated advisories or guidance issued by federal or state government that are not legally binding but that may be considered during development of remedial alternatives. For example, EPA Health Advisories and Reference Doses are non-promulgated criteria that are used to assess health risks from contaminants present on CERCLA sites.

ARARs and TBCs are divided into chemical-specific, location-specific, and action-specific categories. Tables 2-1 through 2-3 present summaries of the ARARs and TBCs identified for each category and their consideration in this FFS. In Sections 2.1.1 through 2.1.3, these categories are briefly described and general types of potential ARARs and TBCs that may be applied to the site are identified. Section 4.0 contains more detailed discussions of the potential ARARs and TBCs for specific remedial alternatives.

TABLE 2-1
POTENTIAL CHEMICAL-SPECIFIC ARARS AND TBCS
FEASIBILITY STUDY REPORT
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION IN THE FS
Federal Regulatory Requirements	Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) (40 CFR 141)	Applicable	MCLs have been promulgated for a number of common organic and inorganic contaminants to regulate the concentration of contaminants in public drinking water supply systems. MCLs are relevant because the aquifer beneath the site is used for drinking water supplies.	MCLs were used to determine clean-up criteria for the aquifer.
	SDWA Maximum Contaminant Level Goals (MCLGs)(40 CFR Part 141))	Applicable	MCLGs are health-based limits for contaminant concentrations in drinking water. MCLGs are established at levels at which no known or anticipated adverse effects on human health are anticipated and that allow for an adequate margin of safety. MCLGs are set without regard for cost or feasibility.	Non-zero MCLGs may be used as clean-up levels if conditions at the site justify setting groundwater clean-up levels lower than MCLs.
Federal Advisories and Guidance	SDWA Secondary Maximum Contaminant Levels (SMCLs) (40 CFR Part 143)	Applicable	SMCLs are non-enforceable guidelines developed for contaminants that may adversely affect the aesthetic quality of drinking water such as taste, odor, color, and appearance.	SMCLs were considered to determine clean-up criteria for the aquifer.
	Federal Ambient Water Quality Criteria (AWQCs) (40 CFR 131)	Applicable	AWQCs are non-enforceable guidelines developed for pollutants in surface waters. AWQCs are available for the protection of human health from exposure to contaminants in drinking water as well as from ingestion of aquatic biota and for the protection of fresh and saltwater aquatic life.	Requirements were considered to determine the level of groundwater treatment necessary because treated groundwater may be discharged to surface water bodies.
Commonwealth of Pennsylvania Requirements	Pennsylvania Safe Drinking Water Act (25 PA Code, Chapter 109)	Applicable	Sets forth drinking water quality standards at least as stringent as the federal standards. MCLs that are promulgated by EPA are automatically incorporated into the Pennsylvania SDWA. If an MCL does not exist for a contaminant, the Pennsylvania SDWA requires that a maximum allowable concentration be determined through a series of established, hierarchical criteria.	MCLs were used to determine clean-up criteria for the aquifer.
Commonwealth of Pennsylvania Advisories and Guidance	Land Recycling and Environmental Remediation Standards Act	Applicable	Contains the statewide human health standards [MCLs or Health Advisory Levels (HALs)] for groundwater.	The human health standards were used to determine clean-up criteria for the aquifer.

AR300209

TABLE 2-2
POTENTIAL LOCATION-SPECIFIC ARARS AND TBCS
FEASIBILITY STUDY REPORT
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION IN THE FS
Federal Regulatory Requirements	Federal Protection of Wetlands Executive Order (E.O. 11990)	To Be Determined	Federal agencies are required to minimize the destruction, loss, or degradation of wetlands and preserve and enhance the natural and beneficial values of wetlands.	Wetlands protection consideration will be incorporated into the planning and decision making for remedial alternatives.
	Fish and Wildlife Coordination Act of 1980 (16 USC 661)	To Be Determined	Federal agencies are required to consult with the U.S. Fish and Wildlife Service and with the appropriate state agency exercising jurisdiction or wildlife resources before issuing a permit or undertaking federal action for the modification of any body of water.	EPA must consult with the U.S. Fish and Wildlife Service and the appropriate state agency if a remedial alternative modifies a body of water.
	Fish and Wildlife Conservation Act (16 USC 2901)	To Be Determined	This regulation provides for consideration of the impacts on wetlands and protected habitats.	Wetlands and protected habitats considerations will be incorporated into the planning and decision making for remedial alternatives.
	Fish and Wildlife Improvement Act of 1978 (16 USC 742a)	To Be Determined	This regulation provides for consideration of the impacts on wetlands and protected habitats.	Wetlands and protected habitats considerations will be incorporated into the planning and decision making for remedial alternatives.
	Endangered Species Act of 1978 (16 USC 1531) (40 CFR 502)	To Be Determined	Federal agencies are required to ensure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any endangered or threatened species or adversely affect its critical habitat.	Endangered species and habitat protection considerations will be incorporated into the planning and decision making for remedial alternatives.
	National Historical Preservation Act of 1966 (36 CFR 65)	To Be Determined	This regulation develops procedures for the identification, designation, recognition, and protection of buildings, structures, sites, and objects of national significance that commemorate and illustrate the history and culture of the United States.	
	Protection of Archeological Resources Act of 1979 (32 CFR Part 229; 43 CFR Parts 107 and 171)	To Be Determined	This regulation develops procedures for the protection of archeological resources, which are defined in the Act as material remains of past human life or activities that are of archeological interest (at least 100 years old).	Any archeological resources encountered during excavation activities will be reviewed by federal and state archeologists.
Commonwealth of Pennsylvania Requirements	The Stormwater Management Act (Act No. 167), Ch. 105	To Be Determined	This regulation requires measures to control stormwater runoff during remedial alternatives or development of land, and discusses the procedures and regulations to be followed for activities taking place in or near wetlands.	Wetlands protection consideration will be incorporated into the planning and decision making for remedial alternatives.
	Historic Preservation Act, 71 P.S. Sections 1047 et seq.	To Be Determined	This regulation develops procedures for the identification, designation, recognition, and protection of buildings, structures, sites, and objects of historical significance within the commonwealth.	Any archeological resources encountered during excavation activities will be reviewed by federal and state archeologists.

AR300210

TABLE 2-3
POTENTIAL ACTION-SPECIFIC ARARS AND TBCS
FEASIBILITY STUDY REPORT
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION IN THE FS
Federal Regulatory Requirements	Clean Water Act (40 CFR Part)	To Be Determined		
	Hazardous Waste Generator and Transporter Requirements (40 CFR Parts 262 and 263)	Applicable	These regulations establish the responsibilities of generators and transporters of hazardous waste in the handling, transportation, and management of the water. The regulations specify packaging, labeling, record keeping, and manifest requirements.	Activities performed in connection with the off-site transport of hazardous wastes, such as spent carbon units, will comply with the requirements of these regulations.
	Department of Transportation (DOT) Rules for Hazardous Materials Transport (49 CFR Parts 107, 171-179)	To Be Determined	This regulation governs the transport of hazardous materials, including packaging, shipping, equipment, and placarding. These rules apply to wastes shipped off site for laboratory analysis, treatment, or disposal.	Activities performed in connection with the off-site transport of hazardous wastes, such as spent carbon units, will comply with the requirements of these regulations.
	Occupational Safety and Health (OSHA) Act (29 USC 651-678)	Applicable	This regulation governs worker health and safety during implementation of remedial actions.	Worker health and safety considerations will be incorporated into the planning and decision making for remedial alternatives
	National Environmental Policy Act	To Be Determined	This act requires the consideration of environmental effects because of federal actions.	
Commonwealth of Pennsylvania Requirements	Hazardous Waste Management Regs. (25 PA Code, Article VII), Chapters 262 - 263	To Be Determined	Remedial actions may include the treating, storing, transportation, and disposal of hazardous waste.	Activities performed in connection with the management of hazardous wastes will comply with the requirements of these regulations
	Residual Waste Management Regs. (25 PA Code, Article IX), Chapters 281 - 299	To Be Determined	Pretreatment residuals and/or spent carbon determined to be non-hazardous must be managed as residual waste.	Activities performed in connection with the management of residual wastes will comply with the requirements of these regulations
	Special Water Pollution Regulations (25 PA Code, Chapter 101)	To Be Determined	Establishes a procedure for mandatory notification of downstream users in the case of an accident in which a toxic substance enters surface waters.	
	Erosion Control Regulations (25 PA Code, Chapter 102)	To Be Determined	Provides requirements for erosion and sedimentation control plans, permits, etc.	These regulations may be potentially applicable if remedial actions involve disturbance of soils.

AR300211

TABLE 2-3
POTENTIAL ACTION-SPECIFIC ARARS AND TBCS
FEASIBILITY STUDY REPORT
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION IN THE FS
Commonwealth of Pennsylvania Requirements (continued)	Water Well Drillers License Act, 32 P.S. Sections 645 et. seq. (Chapter 107)	To Be Determined	Requires that water supply wells and monitoring wells be drilled by a driller licensed to operate in the Commonwealth of Pennsylvania.	Any and all wells to be drilled as part of any remedial alternative will be drilled by a driller licensed to operate in the commonwealth.
	Hazardous Substances Transportation Regulations, PA Code Titles 13 and 15.	To Be Determined	Requirements that govern the transport of flammable liquids and solids, oxidizing materials, poisons, and corrosive liquids.	Activities performed in connection with the off-site transport of hazardous wastes, such as spent carbon units, will comply with the requirements of these regulations.
	Pennsylvania Workers and Community Right-to-Know Law, Pa. Statute Title 35, Health and Safety, Chapter 41	Applicable	This regulation governs worker health and safety during the implementation of remedial actions.	Worker health and safety considerations will be incorporated into the planning and decision making for remedial alternatives.
Commonwealth of Pennsylvania Advisories and Guidance	Soil Erosion and Sedimentation Control Manual	To Be Determined		

AR300212

2.1.1 Chemical-Specific ARARs and TBCs

Chemical-specific ARARs and TBCs are usually health- or risk-based numerical values that are used to establish the acceptable amount or concentration of a chemical that may remain in or be discharged to the environment. In general, chemical-specific requirements are set for a single chemical or a closely related group of chemicals. These requirements do not consider the mixture of chemicals. Typical chemical-specific ARARs are federal and state drinking water standards. EPA health advisories, reference doses, and carcinogen potency factors are typical chemical-specific TBCs. When available, chemical-specific ARARs and TBCs are used to establish preliminary remediation goals.

Potential chemical-specific ARARs for the Crossley Farm Site include the federal SDWA and state MCLs, which regulate the quality of treated water produced by a public water supply to its users. MCLs are promulgated numerical values that specify the maximum permissible levels of contaminants delivered to a user of public water supplies. MCLs have been promulgated by both the federal government and the commonwealth of Pennsylvania government. There are no regulations governing the use of groundwater by private residences. For this FFS, MCLs may be considered relevant and appropriate in developing options that address contaminated water supplies to residents living near the Crossley Farm Site or applicable if a new public water supply is installed.

2.1.2 Location-Specific ARARs

Location-specific ARARs are restrictions placed on the concentrations of hazardous substances or the conduct of activities solely because they are in specific areas. Several federal and state regulations govern activities in wetlands and floodplains that may result in their degradation. Additional potential location-specific ARARs include the Federal Fish and Wildlife Coordination Act, the national and state historical preservation acts, the federal and state protection of archeological resources acts, the federal and state endangered species regulations, state erosion control regulations, and state stormwater management requirements.

As yet, no site-specific location-specific ARARs, guidances, or policies have been identified for the Crossley Farm Site.

2.1.3 Action-Specific ARARs

Action-specific ARARs are usually technology- or activity-based requirements or limitations on actions taken with respect to hazardous wastes. These requirements are generally focused on actions taken to remediate, handle, treat, transport, or dispose of hazardous wastes. These action-specific requirements do not in themselves determine the remedial alternative; rather, they indicate how a selected alternative must be achieved (EPA/540/G-89/006). The general types of action-specific ARARs that may be applied to the site are briefly described below.

Most action-specific ARARs fall into two primary categories: federal and state regulations pertaining to the Clean Water Act (CWA) and Clean Air Act (CAA). CWA ARARs generally regulate the discharge of treated water. CAA requirements typically pertain to air emissions.

Other action-specific ARARs include hazardous waste generator and transporter requirements, federal hazardous materials transport regulations, and worker occupational health and safety requirements.

2.2 REMEDIAL ACTION OBJECTIVE (RAO)

Remedial action objectives (RAOs) are medium-specific goals for protecting human health and the environment. RAOs should specify contaminants of concern, exposure routes, and acceptable contaminant levels or range of levels for each exposure route. RAOs typically express both a contaminant level and an exposure route, because protectiveness may be achieved by reducing exposure (such as providing an alternate water supply) as well as by reducing actual contaminant levels in the media of concern.

The development of the medium-specific RAO for this FFS was based on the risks posed by contaminated groundwater to residents within the study area who use the underlying overburden or bedrock aquifers, or springs fed by the aquifer, as the sources of private drinking water supplies and through a comparison of detected contaminant levels with drinking water standards.

- Based on the above considerations, the proposed RAO for protection of human health is to prevent human exposures to contaminated water supplies (well water or spring water) that exceed federal or state maximum contaminant levels (MCLs) or result in excess carcinogenic (greater than 1E-4) and noncarcinogenic (HI greater than 1.0) health risks through the ingestion, dermal contact, and inhalation exposure routes.

2.3 PRELIMINARY REMEDIATION GOALS

Preliminary remediation goals (PRGs) are medium-specific numerical concentration values for contaminants that would be protective of human health and the environment. The PRGs are selected to address the proposed RAO. Therefore, the PRGs for this FFS are the numerical concentration values for contaminants present in the groundwater that would be protective of human health if that water were used for the typical household uses of ingestion, bathing, and showering. Based on the preliminary risk assessment results and comparisons with primary drinking water criteria, the following set of PRGs was assembled and is presented in Table 2-4.

Drinking Water Criteria - The federal Safe Drinking Water Act established MCLs that specify the maximum permissible levels of contaminants in finished water produced by public water supplies that is delivered to the public. MCLs also have been promulgated by the commonwealth of Pennsylvania. The MCLs are numerical limits for selected contaminants such that their presence in drinking water supplies does not pose adverse effects to users.

Although federal and state MCLs are not used to regulate the quality of water produced by private water supplies, the numerical limits specified under these regulations can be used to establish one set of PRGs that would be protective of human health for use of groundwater in the study area. Table 2-5 presents the contaminants of concerns identified in the study area and the corresponding federal and state MCLs.

Risk-Based Concentrations (RBCs) - RBC values for nearly 600 chemicals have been developed by EPA Region III that correspond to fixed levels of risks (lifetime carcinogenic risk of 1E-6 or a Hazard Quotient of 1.0 for non-carcinogenic risk) derived using available toxicity factors and "standard" exposure scenarios. The EPA Region III RBCs developed for the use of tap water are presented in Table 2-4.

Table 2-5 presents the list of proposed PRGs for this FFS. The federal Safe Drinking Water Act MCLs were typically selected as the preliminary remediation goals, unless there were more stringent state MCLs. If MCLs are unavailable, then the EPA Region III RBC values were selected.

2.3.1 Identification of Affected Residences

The results of the preliminary risk analysis for each potable source were screened against the remedial action objective to identify the residences where a remedial action is necessary. The results of this analysis are summarized in Table 2-6.

A total of 31 wells were identified as requiring a remedial action. The screening procedure produced a series of observations concerning the groundwater quality of each well relative to MCLs and the risks associated with the evaluated exposure pathways. These observations become germaine to the evaluation of the remedial technologies.

TABLE 2-4

SUMMARY OF PROPOSED PRELIMINARY REMEDIATION GOALS
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE
HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

Contaminant of Concern	SDWA Maximum Contaminant Level[1] (ug/L)	USEPA Region III Risk-Based Concentrations[2] (ug/L)	Pennsylvania Maximum Contaminant Level[3] (ug/L)
Benzene	5	0.36	5
Bromodichloromethane	100	0.17	100
Carbon tetrachloride	5	0.16	5
Chloroform	100	0.15	100
Hexachlorobutadiene	-	0.14	-
Methylene chloride	-	4.1	5
Tetrachloroethene	5	1.1	5
Toluene	1,000	750	1,000
Trichloroethene	5	1.6	5
Trichlorofluoromethane	-	1,300	
1,1-Dichloroethene	7	0.044	7
cis-1,2-Dichloroethene	70	61	70
trans-1,2-Dichloroethene	100	120	100
1,1,2-Trichloroethane	5	0.19	5
Cadmium	5	18	5
Copper	1,300	150	1,000
Iron	-	1,100	-
Lead	15	15	5
Manganese	-	180	50

1 Safe Drinking Water Act Maximum Contaminant Levels are specified under 40 CFR 141.

2 EPA Region III risk-based concentration values for tap water are from the October 1995 quarterly listing and are based on maximum carcinogenic risk of 1E-06 or Hazard Quotient of 1.0.

3 State maximum contaminant levels are specified under the commonwealth of Pennsylvania's Safe Drinking Water Act of 1984 (25 PA Code, Chapter 109).

TABLE 2-5
SELECTED PRELIMINARY REMEDIATION GOALS
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE
HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

Contaminant of Concern	Selected PRG (ug/L)	Basis of Selection
Benzene	5	MCL
Bromodichloromethane	0.001	MCL
Carbon tetrachloride	5	MCL
Chloroform	0.001	MCL
Hexachlorobutadiene	0.14	EPA III RBC
Methylene chloride	5	PA MCL
Tetrachloroethene	5	MCL
Toluene	1000	MCL
Trichloroethene	5	MCL
Trichlorofluoromethane	1300	EPA III RBC
1,1-Dichloroethene	7	MCL
cis-1,2-Dichloroethene	70	MCL
trans-1,2-Dichloroethene	100	MCL
1,1,2-Trichloroethane	5	MCL
Cadmium	5	MCL
Copper	1300	MCL
Iron	1100	EPA III RBC
Lead	15	PA MCL
Manganese	50	PA MCL

1) Preliminary remediation goals are proposed maximum numeric contaminant concentrations, under this focused FS, for the alternate water supply to be provided to residents affected by site-related contamination.

2) Preliminary remediation goals are selected based on SWDA MCLs or PA MCLs if they are more stringent than the federal MCLs or EPA Region III risk-based concentration values if no MCLs are available.

TABLE 2-6
WELL SCREENING VERSUS THE REMEDIAL ACTION OBJECTIVE
CROSSLEY FARM SITE
HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

Well	Risk Total		Risk Ingestion		Risk Dermal		Risk Inhalation		HI Total		HI Ingestion		HI Dermal		HI Inhalation		MCL Exceed?	Require Remedial Action
	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A		
W-29	>E-3	>E-3	>E-3	>E-3	>E-5	>E-5	>E-4	>E-4	>1	>1	>1	>1	>1	>1	<1	<1	X	X
W-19	>E-4	>E-3	>E-4	>E-4	>E-5	>E-5	>E-4	>E-4	>1	>1	>1	>1	>1	>1	<1	<1	X	X
W-8	>E-4	>E-4	>E-5	>E-4	>E-6	>E-6	>E-5	>E-5	>1	>1	>1	>1	<1	<1	(a)	(a)	X	X
W-18	>E-4	>E-4	>E-5	>E-4	>E-6	>E-6	>E-5	>E-5	>1	>1	>1	>1	<1	<1	(a)	(a)	X	X
W-20	>E-4	>E-4	>E-4	>E-4	>E-6	>E-5	>E-5	>E-5	>1	>1	>1	>1	<1	>1	<1	<1	X	X
W-22	>E-4	>E-4	>E-4	>E-4	>E-6	>E-5	>E-5	>E-5	>1	>1	>1	>1	>1	<1	<1	<1	X	X
W-27	>E-4	>E-4	>E-4	>E-4	>E-6	>E-5	>E-5	>E-5	>1	>1	>1	>1	<1	<1	(a)	(a)	X	X
W-28	>E-4	>E-4	>E-5	>E-4	>E-6	>E-6	>E-5	>E-5	>1	>1	>1	>1	<1	<1	(a)	(a)	X	X
W-59	>E-4	>E-4	>E-4	>E-4	>E-6	>E-5	>E-5	>E-5	>1	>1	>1	>1	<1	<1	(a)	(a)	X	X
W-99	>E-4	>E-4	>E-4	>E-4	>E-6	>E-5	>E-5	>E-5	>1	>1	>1	>1	<1	<1	<1	<1	X	X
W-16	>E-5	>E-4	>E-5	>E-5	>E-6	>E-6	>E-5	>E-5	>1	>1	>1	>1	<1	<1	(a)	(a)	X	X
W-2	>E-5	>E-5	>E-5	>E-5	>E-6	>E-6	>E-5	>E-5	>1	>1	>1	>1	<1	<1	<1	<1	X	X
W-5	>E-5	>E-5	>E-5	>E-5	>E-7	>E-6	>E-6	>E-6	>1	>1	>1	>1	<1	<1	(a)	(a)	X	X
W-9	>E-5	>E-5	>E-5	>E-5	>E-6	>E-6	>E-5	>E-5	>1	>1	>1	>1	<1	<1	(a)	(a)	X	X
W-17	>E-5	>E-5	>E-5	>E-5	>E-6	>E-6	>E-6	>E-6	>1	>1	>1	>1	<1	<1	(a)	(a)	X	X
W-24	>E-5	>E-5	>E-5	>E-5	>E-7	>E-6	>E-6	>E-6	>1	>1	>1	>1	<1	<1	<1	<1	X	X
W-58	>E-5	>E-5	>E-5	>E-5	>E-6	>E-6	>E-6	>E-6	>1	>1	>1	>1	<1	<1	<1	<1	X	X
W-61	>E-5	>E-5	>E-6	>E-5	>E-7	>E-7	>E-6	>E-6	>1	>1	>1	>1	<1	<1	(a)	(a)	X	X
W-30	>E-6	>E-5	>E-6	>E-6	>E-7	>E-7	>E-6	>E-6	<1	<1	<1	<1	<1	<1	(a)	(a)	X	X

(a) No RfD available for chemical and/or exposure route
HI: Hazard Index
C: Child Receptor
A: Adult Receptor

See Section 1.4.1 for an explanation and discussion of risk and HI values.

TABLE 2-6
WELL SCREENING VERSUS THE REMEDIAL ACTION OBJECTIVE
CROSSLEY FARM SITE
HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA
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Well	Risk Total		Risk Ingestion		Risk Dermal		Risk Inhalation		HI Total		HI Ingestion		HI Dermal		HI Inhalation		MCL Exceed?	Require Remedial Action
	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A		
W-3	>E-6	>E-6	>E-6	>E-6	>E-8	>E-7	>E-7	>E-7	<1	<1	<1	<1	<1	<1	(a)	(a)	X	X
W-23	>E-6	>E-6	>E-6	>E-6	>E-7	>E-7	>E-7	>E-7	<1	<1	<1	<1	<1	<1	(a)	(a)	X	X
W-25	>E-6	>E-6	>E-7	>E-6	>E-9	>E-8	>E-7	>E-7	<1	<1	<1	<1	<1	<1	<1	<1	X	X
W-26	>E-6	>E-6	>E-7	>E-6	>E-8	>E-8	>E-7	>E-7	<1	<1	<1	<1	<1	<1	<1	<1	X	X
W-41	>E-6	>E-6	>E-6	>E-6	>E-8	>E-7	>E-7	>E-7	<1	<1	<1	<1	<1	<1	<1	<1	X	X
W-42	>E-6	>E-6	>E-6	>E-6	>E-8	>E-7	>E-7	>E-7	<1	<1	<1	<1	<1	<1	(a)	(a)	X	X
W-137	>E-6	>E-6	>E-6	>E-6	>E-7	>E-7	>E-6	>E-6	<1	<1	<1	<1	<1	<1	(a)	(a)	X	X
W-53	>E-6	>E-6	>E-7	>E-7	>E-9	>E-9	>E-6	>E-6	<1	<1	<1	<1	<1	<1	(a)	(a)		
W-124	>E-6	>E-6	>E-7	>E-6	>E-8	>E-7	>E-8	>E-8	<1	<1	<1	<1	<1	<1	(a)	(a)		
W-4	>E-7	>E-6	>E-7	>E-7	>E-8	>E-8	>E-7	>E-7	<1	<1	<1	<1	<1	<1	(a)	(a)	X	X
W-35	>E-7	>E-6	>E-7	>E-6	>E-9	>E-8	>E-7	>E-7	<1	<1	<1	<1	<1	<1	<1	<1	X	X
W-40	>E-7	>E-6	>E-7	>E-6	>E-9	>E-8	>E-7	>E-8	<1	<1	<1	<1	<1	<1	<1	<1	X	X
W-110	>E-7	>E-6	>E-7	>E-6	>E-8	>E-8	>E-7	>E-7	<1	<1	<1	<1	<1	<1	(a)	(a)	X	X
W-52	>E-7	>E-7	>E-7	>E-7	>E-8	>E-8	>E-7	>E-8	<1	<1	<1	<1	<1	<1	(a)	(a)	X	X
W-31	>E-7	>E-7	>E-7	>E-7	>E-8	>E-8	>E-7	>E-7	<1	<1	(a)	(a)	(a)	(a)	<1	<1		
W-54	>E-7	>E-7	>E-8	>E-8	>E-10	>E-9	>E-7	>E-7	<1	<1	<1	<1	<1	<1	(a)	(a)		
S-71	>E-7	>E-7	>E-8	>E-7	>E-8	>E-8	>E-8	(a)	<1	<1	<1	<1	<1	<1	(a)	(a)		
W-72	>E-7	>E-7	>E-7	>E-7	>E-9	>E-8	>E-8	>E-8	<1	<1	<1	<1	<1	<1	(a)	(a)		
W-107	>E-7	>E-7	>E-8	>E-8	>E-10	>E-10	>E-7	>E-7	<1	<1	<1	<1	<1	<1	(a)	(a)		
W-33	>E-8	>E-8	>E-8	>E-8	>E-10	>E-10	>E-8	>E-8	<1	<1	<1	<1	<1	<1	(a)	(a)		

(a) No RfD available for chemical and/or exposure route
HI: Hazard Index
C: Child Receptor
A: Adult Receptor

See Section 1.4.1 for an explanation and discussion of risk and HI values.

The following observations summarize the analytical history of the wells relative to the MCLs and the risks associated with the evaluated exposure pathways:

- A total of 31 wells have had at least one historical detection of a contaminant of concern above the federal primary drinking water criteria (MCLs).

- Two of the 31 wells (W-30 and W-137) with at least one historical detection of a contaminant of concern above MCLs are public water supply wells that provide water to a mobile home park. The carcinogenic risks associated with the raw water from these wells are less than 1E-4 and the noncarcinogenic risks are represented by a Hazard Index of less than 1.0. These wells will not be considered further in this FFS because they are permitted wells that are required to periodically monitor groundwater quality and to provide potable water that meets the MCLs to its customers (the residents). The water from these wells is currently treated by granular activated carbon (GAC) prior to distribution.

- A total of 11 wells produce water for which use results in total carcinogenic risks (for adult residents) in excess of the acceptable risk range (greater than 1E-4). Most of this risk is associated with the ingestion pathway. The inhalation pathway alone produces unacceptable risks in two of these wells (W-19 and W-29).

- A total of 18 wells (including the 11 wells discussed above) produce water whose use results in a total noncarcinogenic risk in excess of the acceptable risk range (Hazard Index greater than 1.0). Again, most of the risk is associated with the ingestion pathway. The dermal pathway alone produces unacceptable risks in four of these wells (W-19, W-29, W-20, and W-22). One well (W-99) has Hazard Indices below 1.0 for both the inhalation and dermal contacts, but the cumulative Hazard Index for these two pathways is above 1.0.

- Therefore, a total of 29 wells have been identified as requiring remediation because their water exceeds MCLs; 18 of these wells have been identified as producing water for which use results in unacceptable carcinogenic and/or noncarcinogenic risks (mostly through the ingestion pathway); five of these 18 wells have been identified where the elimination of carcinogenic and noncarcinogenic risks associated with the ingestion pathway alone would not meet the remedial action objective (W-19, W-29, W-20, W-99, and W-22).

2.4 GENERAL RESPONSE ACTIONS

The Remedial Action Objective (RAO) was used to develop general response actions that describe medium-specific measures to satisfy the RAO. General response actions presented in OSWER Directive No. 9355.3-01, Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, were evaluated for their applicability to site-specific conditions.

The general response actions for contaminated water supplies are

- No action
- Institutional controls
- Treatment
- New water supply

2.5 INITIAL IDENTIFICATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

In this stage, technologies that may be applicable to the remediation of residential water supplies at the Crossley Farm Site were identified and screened to eliminate those that are obviously ineffective or difficult to implement for the given contaminants and site conditions.

Using the set of general response actions developed to address the protection of human health RAO, potential remedial technologies and process options were identified and screened according to their overall technical implementability (or applicability) to the media of concern, primary contaminants (VOCs and metals), and site-specific conditions. The purpose of this screening effort was to investigate a spectrum of available technologies and process options and to eliminate those obviously not applicable to the site based on the proposed RAO and general response actions. Table 2-7 presents a summary of the initial screening of technologies and process options.

2.6 DETAILED SCREENING AND SELECTION OF TECHNOLOGIES AND PROCESS OPTIONS

Further screening of the technologies and process options that passed initial screening was conducted to further focus the alternatives development process. In this step, process options were evaluated with respect to other processes in the same technology category. If possible, one representative process option was selected for each technology type to simplify the subsequent development and evaluation of alternatives without limiting flexibility during remedy selection.

TABLE 2-7
PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
FOR CONTAMINATED WATER SUPPLIES
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	DESCRIPTION	SCREENING COMMENTS
No Action	No Action	No Action	No activities conducted to address contamination.	Retained for baseline comparison purposes in accordance with NCP, 40 CFR §300.430 (e).
Institutional Controls	Institutional Controls	Deed Restrictions and Notices	Administrative action used to restrict future and current activities on individual properties. Installation of private wells and use of untreated groundwater in the area of influence may be restricted using property deeds.	Potentially applicable.
		Local Ordinances	Administrative action used to restrict installation of water supply wells and use of untreated groundwater in the vicinity of the site.	Potentially applicable.
	Monitoring	Groundwater Monitoring	Periodic sampling/analysis of media to assess private drinking water supply quality and contaminant migration status.	Potentially applicable.
Treatment	Physical	Equalization	Dampening of flow and/or contaminant concentration variation in a large vessel to promote constant discharge rate and water quality.	Potentially applicable as a pre-treatment process. Would not address contaminants of concern.
		Dewatering	Mechanical removal of free water from treatment residuals using equipment such as a filter press or vacuum filter.	Potentially applicable if sludge dewatering is required. Would not address contaminants of concern.
		Sedimentation	Gravity settling of suspended solids from water in a vessel.	Potentially applicable if high suspended solids content is encountered.

TABLE 2-7
PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
FOR CONTAMINATED WATER SUPPLIES
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	DESCRIPTION	SCREENING COMMENTS
Treatment	Physical (continued)	Oil/Water/NAPL Separation	Separation of oils or other non-aqueous-phase liquids from water by force of gravity.	Potentially applicable, if NAPLs are present in groundwater.
		Filtration	Separation of material from water via entrapment in a bed or membrane separation.	Potentially applicable.
		Reverse Osmosis	Use of high pressure and membranes to separate dissolved materials, including organics and inorganics, from water.	Potentially applicable.
		Air Stripping	Transfer of volatile organic compounds from the aqueous phase to the vapor phase through contact of contaminated water with air or steam in a countercurrent process.	Potentially applicable.
		Carbon Adsorption	Adsorption of aqueous-phase contaminants onto activated carbon.	Potentially applicable.
		Extraction	Separation of contaminants from a solution by contact with an immiscible liquid with a higher affinity for the contaminants of concern.	Not effective on wastes containing a mixture of different contaminants.
		Distillation	Vaporization of a liquid followed by condensation of the vapors by cooling.	Not effective on wastes containing dilute mixtures of different contaminants.
		Evaporation	Change from the liquid to the gaseous state at a temperature below the boiling point.	Not effective on wastes containing dilute mixtures of different contaminants.

TABLE 2-7
PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
FOR CONTAMINATED WATER SUPPLIES
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
Treatment (continued)	Chemical	Electrodialysis	Recovery of anions or cations using special membranes under the influence of an electrical current.	Not suited to treatment of contaminated groundwater; technology typically utilized for treatment of high concentration waste streams.
		Detonation	Detoxification of explosive waste by setting off a charge.	Not effective on the contaminants of concern since they are not explosive.
		Disinfection	Addition of chemical agents or use of radiation to kill or render inactive water-borne pathogenic microorganisms.	Potentially applicable, if municipal water supply is considered.
		Ion exchange	Process in which toxic ions are removed from the aqueous phase by being exchanged with relatively harmless ions held by electrostatic forces to a specifically formulated resin.	Potentially applicable to site contaminants of concern.
		Electrolytic Recovery	Passage of an electric current through a solution with resultant ion recovery on positive and negative electrodes.	Not suited to treatment of contaminated groundwater; technology typically used for treatment of high concentration waste streams.
		Oxidation	Use of strong oxidizing agents such as chlorine, hydrogen peroxide, ozone, UV light, or potassium permanganate to chemically increase the oxidation state of materials in order to reduce their toxicity or solubility.	Potentially applicable.

TABLE 2-7
PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
FOR CONTAMINATED WATER SUPPLIES
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
Treatment (continued)	Chemical (continued)	Reduction	Use of strong reducers such as ferrous iron, sulfur dioxide, or sulfite to chemically reduce the oxidation state of materials in order to reduce their toxicity or solubility.	Contaminants present are not amenable to reduction. Not applicable for organics, primarily for reduction of hexavalent chromium, mercury, and lead.
		Neutralization	Use of acids or bases to counteract excessive pH levels or to optimize pH for a specific treatment process.	Potentially applicable as a conditioning step to facilitate treatment.
		Precipitation	Use of reagents to convert soluble materials into insoluble materials.	Potentially applicable.
		Coagulation-Flocculation	Use of chemicals to neutralize surface charges and promote attraction of colloidal particles to facilitate settling.	Potentially applicable.
		Dechlorination	Use of chemicals to remove chlorine from chlorinated compounds.	Typically utilized for high-concentration wastewater streams. Not effective on waste streams containing a dilute mixture of different contaminants.
	Biological	Aerobic	Suspended growth or fixed-film process employing aeration and biomass recycle to decompose organic contaminants.	Not applicable for drinking water supply treatment.
		Anaerobic	Suspended growth or fixed-film process employing anaerobic bacteria to decompose organic contaminants in an oxygen-free environment.	Not applicable for drinking water supply treatment.

TABLE 2-7
PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
FOR CONTAMINATED WATER SUPPLIES
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
New Water Supply	New Water Supply	Delivered Water	Either bottled or bulk quantities of potable water would be provided to each affected residence.	Potentially applicable.
		Water Line	An existing municipal water supply system would extend a distribution line to the homes with contaminated wells.	Potentially applicable.
		New Private Supply Wells	New supply wells would be installed for each affected residence.	Potentially applicable.
		New Community Supply Wells	A new municipal well field would be located, and a municipal water supply would be established.	Potentially applicable.

The evaluation of technologies and process options utilizes three criteria: effectiveness, implementability, and relative cost. The OSWER Directive 9355.3.01, Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, EPA/540/G-89/004, suggests that this evaluation focus on the effectiveness criterion, with less emphasis directed at the implementability and relative cost criteria.

Brief definitions of effectiveness, implementability, and relative cost, as they apply to the evaluation process, follow:

- Effectiveness - This criterion focuses on the potential effectiveness of process options in handling the estimated volume of media and meeting the remediation goals; the potential impacts to human health and the environment during construction and implementation; and how proven and reliable the process is with respect to the contaminants and conditions at the site.

- Implementability - The implementability evaluation encompasses both the technical and institutional feasibility of implementing a process. Technical implementability was used as an initial screen of technology types and process options to eliminate those that are clearly ineffective or unworkable. Therefore, this subsequent, more detailed evaluation of process options places greater emphasis on the institutional aspects of implementability, such as the ability to obtain permits, availability of RCRA treatment, storage, and disposal (TSD) services, and availability of necessary equipment and resources.

- Cost - Cost plays a limited role in this screening. The cost analysis is based on engineering judgment, and each process is evaluated as to whether costs are high, low, or medium relative to the other options in the same technology type. If there is only one process option, costs are compared to other candidate technologies.

The technologies and process options that passed the initial screening are presented in Table 2-8. All of the evaluation criteria presented above may not apply directly to each technology and, therefore, are addressed as appropriate in the evaluation of each technology. As indicated above, screening evaluations at this stage generally focus on effectiveness and implementability, with less emphasis on cost evaluations. At this stage, no technologies are eliminated based on cost. However, technologies or process options of equal effectiveness will be screened to identify the lowest cost option for further evaluation. Each technology presented in this section is not necessarily intended to be implemented alone; it may be combined with other technologies into remedial action alternatives. The detailed screening of technologies and process options is presented in Sections 2.6.1 through 2.6.4.

TABLE 2-8

TECHNOLOGIES AND PROCESS OPTIONS PASSING PRELIMINARY SCREENING FOR CONTAMINATED WATER SUPPLIES
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE
HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION
No Action	No Action	• No action
Institutional Controls	Institutional Controls	• Deed restrictions and notices • Local ordinances
	Monitoring	• Groundwater monitoring
Treatment	Physical	• Filtration • Reverse osmosis • Air stripping • Carbon adsorption
	Chemical	• Disinfection • Ion exchange • Precipitation • Coagulation-flocculation
New Water Supply	New Water Supply	• Delivered water • Water line • New private supply wells • New community supply wells

2.6.1 No Action

The NCP, per 40 CFR 300.430, requires that a no-action scenario be considered in order to provide a baseline level to which other remedial technologies and alternatives can be compared. Under the no-action scenario, neither provision of an alternate water supply to affected residents nor removal or treatment of contaminated groundwater would occur.

Effectiveness - The no-action option would not achieve the RAO. Human health risks associated with exposure to carcinogenic and non-carcinogenic contaminants in groundwater would continue over time as a result of continued use of contaminated groundwater that migrates from the site. Other effectiveness criteria are not applicable for the no-action scenario.

Implementability - There are no implementability considerations associated with the no-action scenario.

Cost - Because no actions other than 5-year reviews of site status would be taken, there would be no capital costs, and operation and maintenance (O&M) costs would be low.

Conclusion - Retain the no-action scenario as a baseline, as required by the NCP.

2.6.2 Institutional Controls

Institutional controls are actions that do not involve engineering actions or treatment to reduce potential health threats or mitigate contamination. Institutional controls can include such options as deed restrictions and notices, local ordinances, access restrictions, and monitoring. Under institutional controls, no active removal or treatment of contaminated groundwater is conducted to reduce or prevent potential human exposure.

2.6.2.1 Deed Restrictions and Notices

Deed restrictions are placed on property deeds to restrict or limit future site activities to prevent human contact with contaminated groundwater. Deed restrictions that may be used include restrictions on types of development allowed (i.e., no residential use) or limitations on use of groundwater without prior treatment. Deed notices are incorporated into the deed to inform prospective purchasers of contaminant presence at the property.

Effectiveness - Deed restrictions could be applied to limit future land use activities that would result in potential exposures. However, historically, these restrictions by themselves have not proven to be reliable and are difficult to enforce. Deed restrictions and notices alone are not effective in the long term to reduce risk and would not achieve the RAO. Because of the lack of an alternate water supply and the cost of bottled water or household-size treatment units, current property owners could still use the groundwater despite restrictions or notices.

Naturally occurring microorganisms can gradually degrade the VOCs to simpler and less toxic constituents; however, this can be a prolonged and heterogeneous process. Due to the considerable length of time that would be required for this process to occur at the contaminant concentrations detected in the area groundwaters, natural attenuation is not considered feasible at the Crossley Farm Site.

There are no potential impacts to human health or the environment through the implementation of deed restrictions or notices.

Implementability - Deed restrictions may be implemented by the property owners or by state and local authorities. Because each property belongs to a different owner and because owners may be reluctant, attaching restrictions and notices to deeds may be difficult. The state and local authorities may have to go through arduous administrative procedures to impose restrictions and notices on deeds. Deed restrictions and notices are typically difficult to implement and to enforce.

Consideration of the availability of treatment, storage, and disposal (TSD) facilities and the need for permits are not applicable to deed restrictions.

Cost - Deed restrictions and notices only require administrative actions and would result in low capital costs. No long-term O&M costs would be incurred.

Conclusion - Deed restrictions are likely to be difficult to implement and to enforce. Although deed restrictions and notices would not cost very much to implement, they may indirectly depress property values. Deed restrictions and notices are generally ineffective measures in preventing the use of contaminated water.

2.6.2.2 Local Ordinances

Local ordinances are administrative actions enacted by municipalities to limit property use or activities. Local ordinances used to reduce exposure to contaminated media may include zoning by-laws and Board of Health regulations that limit private well installation or use of groundwater without treatment.

Effectiveness - Local ordinances may reduce the exposure to contaminated groundwater by controlling the installation of new wells or use of contaminated groundwater. Effectiveness of ordinances is highly dependent on enforcement by local authorities and compliance by the public. For the same reasons cited for deed restrictions, some current residents would still use underlying groundwater and be exposed.

There are no potential impacts to human health or the environment through the implementation of local ordinances.

Implementability - Although enforcement may be possible, it would probably be difficult because this type of ordinance would be disruptive of residences. The RAO to protect human health would not likely be achieved by local ordinances. Local ordinances may be viable, if enforced, as a means of limiting exposure to contaminated groundwater.

Consideration of the availability of TSD facilities and the need for permits are not applicable to local ordinances.

Cost - Implementation of ordinances is generally low cost. However, enforcement would result in moderate costs because of the labor involved and because long-term action will be required.

Conclusion - Local ordinances are probably more easily implemented than deed restrictions or notices and may provide some protection of human health if they can be enforced. However, enforcement would likely be difficult.

2.6.2.3 Access Restrictions

Fencing may be used as a barrier to restrict access to contaminated springs, thereby limiting direct contact exposure. Currently, access to springs is unrestricted. Fencing would limit access and provide some reduction in potential exposure to contaminated groundwater.

There are no potential impacts to human health or the environment through the implementation of access restrictions.

Effectiveness - Fencing would not meet the RAO because it only provides limited protection of human health by discouraging trespassers access to areas where contaminated springs are present. The effectiveness of fencing in reducing access and thereby reducing exposure to contaminants is highly dependent on fence maintenance and on the determination of the would-be trespasser. Fencing would not be effective in the long term to prevent exposure or eliminate risk.

Implementability - Installing new fencing and maintaining fencing are easily implementable actions. There may be some difficulty in implementing access restrictions on properties where the owners are unwilling.

Consideration of the availability of TSD facilities and the need for permits is not applicable to access restrictions.

Cost - The capital and O&M costs for fencing would be low.

Conclusion - Fencing can reduce, but not prevent, potential exposure to contaminated springs.

2.6.2.4 Monitoring

Groundwater is monitored periodically to identify potential groundwater contamination migration patterns and evaluate whether areas downgradient of the Crossley Farm Site may be affected. Residential well supplies can be monitored to assess the quality of water being used and to alert the responsible agency of the need to enact measures to prevent or mitigate exposures. Although monitoring would not directly limit exposure to contaminants, it could limit potential future exposure by serving as an early warning mechanism.

Effectiveness - Monitoring would not achieve the RAO for protection of human health. Monitoring can only serve as a warning mechanism. Monitoring may be combined with other measures to offer a greater level of protection. Monitoring is a standard procedure that has been used on numerous sites to assess contaminant status and migration patterns.

There are no potential impacts to human health or the environment through the implementation of periodic groundwater monitoring.

Implementability - Monitoring would be readily implementable since sampling and analysis techniques are routine actions. There would be no shortage of equipment or resources to perform sampling.

Consideration of the availability of TSD facilities and the need for permits is not applicable to access restrictions.

Cost - No capital costs are associated with monitoring. However, O&M costs can be substantial if numerous residences need to be assessed for a long duration.

Conclusion - Monitoring would not achieve the RAO because monitoring only indicates whether contaminants are present in groundwater and serves as a mechanism to alert the responsible agency of the need for potential actions. Periodic monitoring of nearby residential wells could be a viable means of assessing potential impacts on private drinking water supplies and evaluating whether actions are necessary to prevent exposures.

2.6.3 Treatment

Under this technology type, contaminated groundwater would be treated with one or a combination of methods. In this section, treatment technologies for the removal of the contaminants are presented.

Treatment technologies that may be required for water conditioning before or after primary treatment, such as filtration or sedimentation for the removal of suspended solids, are also included. Ideally, treatment would reduce contaminant concentrations to below PRGs or MCLs. The technologies considered are

- Air stripping
- Carbon adsorption
- Disinfection
- Filtration
- Oxidation
- Precipitation/coagulation-flocculation
- Reverse osmosis

2.6.3.1 Air Stripping

Air stripping is an aeration process that utilizes counter-current air flow to encourage the transfer of VOCs from the aqueous phase to the vapor phase. Carrier gas, such as air or steam, is purged through the contaminated water. Volatile compounds with greater affinity for the gas phase than the aqueous phase will partition to the air and be subsequently removed from the stripper by fans or blowers. Removal efficiencies of 50 percent to more than 99 percent can be achieved for VOCs, depending on operating conditions, column stripper sizing, packing material, and physical and chemical properties of the organic contaminant(s). In general, air stripping is effective for VOCs with a Henry's Law Constant greater than or equal to 3.0 atm-L/mole. However, significant concentrations of other organics can hinder the removal of VOCs, especially when low discharge concentrations are desired. Air stripping alone would not provide for the removal of less or non-volatile organics and metals.

The counter-current packed tower or packed column is the most commonly used air-stripping configuration. Water is distributed over the top of the unit while air is forced upward through the bottom. Loosely fitted packing material serves to increase the air/water interface area to provide maximum mass transfer. Another increasingly common configuration is the low-profile air stripper, which consists of one or a series of aeration trays in place of a tower. The contaminated water is sprayed into the inlet chamber and flows along the baffled aeration tray(s). Air is blown up through hundreds of small holes in the tray(s), forming a froth of bubbles that provide a large mass transfer surface area where volatilization occurs. Key factors that influence air stripping process performance include air-to-water ratio, type of packing material or tray configuration, operating temperature, surface hydraulic loading, and contact time.

Steam stripping is similar to air stripping, except that steam, rather than air, is used as a carrier gas and provides heat to enhance removal of contaminants. Steam stripping is generally considered for product recovery, for enhanced removal of VOCs from highly contaminated waste streams, and for removal of less volatile organic compounds.

Packed tower aeration (PTA) is designated a best available technology (BAT) under the National Primary Drinking Water Regulations Implementation (40 CFR §142.62) for a number of VOCs, including some detected in site groundwater (TCE, PCE, carbon tetrachloride, cis-1,2-dichloroethene, 1,1,1-trichloroethane, and 1,1,2-trichloroethane).

Effectiveness - Air stripping is a well-proven and reliable technology that would be effective for removing the VOCs from groundwater found at the site. Removal efficiencies greater than 99 percent can theoretically be achieved for the site contaminants of concern (TCE, PCE, 1,1-dichloroethene). Steam stripping and air stripping would be similarly effective for treating the contaminant concentrations anticipated for most of the treatment duration.

Since the stripping process only removes the contaminants from the water and concentrates them in the offgas, the offgas may have to be treated by other means (e.g., granular activated carbon adsorption, condensation, catalytic oxidation, or thermal destruction) to meet state air emissions requirements. The need and type of offgas treatment depend on the specific contaminants and their concentrations. It is likely that offgas treatment would be required for the treatment of site groundwater.

Implementability - Air stripping and steam stripping would be readily implementable at the site. The equipment and resources necessary to implement air and steam stripping are readily available from commercial vendors. To meet Pennsylvania air quality standards, treatment of vapor emissions may be required. Due to the addition of steam, the steam stripping process may result in a somewhat higher volume waste stream than air stripping; however, condensation of organics and recycling of process water could minimize excess waste.

A maintenance problem associated with air stripping towers is the channeling of flow resulting from clogging in the packing material. Common causes of clogging include high oils, suspended solids, and iron concentrations and slightly soluble salts such as calcium carbonate. These problems can be mitigated with effective pre-treatment of the influent.

Air stripping systems are typically available for commercial and industrial applications. Air stripping systems for residential applications are available only through a limited number of firms since these units have to comply with federal Food and Drug Administration regulations. Typical systems for residential units can treat up to 8 gallons per minute (gpm), depending on the types of contaminants present.

Cost - The capital costs of air stripping are low, and O&M costs range from low to moderate depending on influent contaminant concentrations, the degree of removal required, and the type of offgas treatment required. The capital costs of steam stripping are moderate, and O&M costs are moderate to high, primarily because of increased energy costs.

Conclusion - Air stripping (PTA) is an effective and reliable technology for removal of most site VOCs from groundwater and is available for both point-of-use and municipal treatment systems; it is therefore retained for further consideration. Steam stripping may be somewhat more efficient than air stripping for treating very high concentrations of organics, if such conditions are encountered. However, because steam stripping is much more expensive to operate, would not provide more effective treatment, would not be available for point-of-use systems, and would generate a higher volume waste stream than air stripping, it will be eliminated from further consideration.

2.6.3.2 Carbon Adsorption

Activated carbon adsorption is a frequently applied technology to remove organic compounds from contaminated water. Activated carbon will adsorb many organic compounds to some extent but is most effective for the less polar and less soluble compounds. Removal efficiency exceeding 99 percent is possible depending on the type of organic contaminants present and system operating parameters, such as retention time and carbon replacement frequency. The fundamental principle behind activated carbon treatment involves the physical attraction of organic solute molecules to exchange sites on the internal pore surface areas of the specially treated (activated) carbon grains. As water is filtered through the adsorbent, the organic molecules eventually occupy all the surface sites on the carbon grains. The exhausted or "spent" carbon must then be either regenerated or disposed according to federal (RCRA) or state regulations.

Typical activated carbon adsorption treatment systems include gravity-flow or pressure-flow columns in series configuration with backwashing capability. Granular activated carbon (GAC) is generally used in these systems. Common flow rates range from 0.5 to 10.0 gpm per square foot. Factors such as pH and temperature of the influent, empty bed contact time (EBCT), surface area/volume ratio of the activated carbon, and solubility of the organic compound will affect the carbon adsorption process. The carbon usage is related to the EBCT, contaminant concentrations, desired effluent concentrations, and desired filter life.

High organic content in the influent can result in high carbon usage. Pretreatment can significantly extend the carbon's useful life, thereby reducing the need for carbon replacement or regeneration. Activated carbon units have been used to "polish" or final treat the water that has undergone other treatment processes, which have removed the bulk of contaminants.

GAC is designated a best available technology (BAT) under the National Primary Drinking Water Regulations Implementation (40 CFR §142.62) for a number of VOCs including some detected in site groundwater (TCE, PCE, carbon tetrachloride, cis-1,2-dichloroethene, 1,1,1-trichloroethane, and 1,1,2-trichloroethane).

Effectiveness - Carbon adsorption is a well-proven, reliable technology to remove organics from aqueous waste streams. Carbon adsorption would be effective in removing many of the organic compounds present in site groundwater. However, activated carbon has low sorptive capacities for vinyl chloride, which will not be effectively or efficiently removed (vinyl chloride has not been detected in groundwater from the Crossley Farm Site but may eventually appear because it is the end product of the degradation process of certain chlorinated solvent compounds, including TCE and PCE). One potential impact to human health is the potential for bacterial growth on the carbon beds and resultant excess bacterial counts in the treated effluent. This condition may be addressed through periodic replacement of the carbon units.

Implementability - Carbon adsorption would be readily implementable. There are a sufficient number of vendors that provide carbon adsorption units. Carbon units can easily fit inside residences and are readily plumbed into the water lines. Therefore, no external, winterized housing structures need to be constructed. Implementation factors also include planning for regeneration or disposal of the spent carbon. Thermal, steam, and solvent treatments are the most common types of regeneration technologies. Regeneration services, which are typically conducted off site, are generally provided by the carbon suppliers. If regeneration is conducted on site, special handling and disposal of the backwash liquids must also be taken into account. Spent carbon would likely require disposal in a RCRA hazardous waste facility. Such facilities are available.

A number of vendors are available who can provide activated carbon units for either commercial/industrial applications or for use in whole-house residential applications.

Cost - Capital costs are low and O&M costs range from low to high, depending on the carbon usage rate, which is a function of influent contaminant concentration and the sorptive capacities of the contaminants. Highly contaminated waste streams, such as the site groundwater, cause carbon to become spent very quickly, necessitating replacement. Waste streams containing compounds with low sorptive capacities will also result in high carbon exhaustion rates. The process becomes expensive because of carbon regeneration or disposal costs and the added "down-time" associated with frequent regeneration or replacement of the carbon beds.

Conclusion - Activated carbon adsorption is a readily implementable technology that would effectively remove many organic compounds from contaminated site groundwater. Based on its effectiveness and the high costs associated with its use as a primary groundwater treatment step, activated carbon adsorption may be best suited as a secondary treatment or a final polishing step rather than as a primary treatment process. This technology will be retained for further consideration as a supporting treatment technology.

2.6.2.3 Disinfection

Disinfection is a treatment process that inactivates or kills waterborne pathogenic microorganisms (i.e., bacteria, Giardia lamblia cysts, and enteric viruses) that may cause the occurrence and transmission of harmful diseases. Treatment of public water supplies is required to eliminate or prevent growth of these pathogens. Primary disinfection is conducted to inactivate pathogens to the desired levels. Secondary disinfection imparts a stable disinfectant residual in the treated water to prevent the growth of microorganisms within the distribution system. Amendments to the 1986 Safe Drinking Water Act have resulted in stringent criteria for disinfection and disinfection by-products and residuals. As a result, provision of a public water supply necessitates considering disinfection as an important treatment component.

Chlorine, chlorine dioxide, ozone, and ultraviolet (UV) radiation are major primary disinfectants. Chlorine and chlorine dioxide are also major secondary disinfectants. A number of the disinfectants also are chemical oxidizers that, to varying degrees of effectiveness, degrade organic compounds. These properties are discussed under Section 2.6.3. Brief summaries for each disinfection agent are provided below:

> Chlorine: Chlorine has been widely used throughout the world as a highly effective disinfecting agent; it is used for both primary and secondary disinfection. Chlorine can be applied as a gas, solid [as calcium hypochlorite ($Ca[OCl_2]$)], and liquid [sodium hypochlorite (NaOCl)]. When added to water, chlorine gas forms hydrochloric (HCl) and hypochlorous (HOCl) acids and the hypochlorite ion (OCl). Hypochlorous acid is the most effective chlorine disinfectant, and hypochlorite ion is less effective. Factors that affect chlorine's disinfection efficiency include pH, contact time, temperature, degree of mixing, and available free chlorine (EPA/625/4-89/023, 1990).
>
> Chlorine is also a strong oxidizing agent and readily reacts with other chemicals in water. Chlorination can cause the oxidation of organic chemicals into trihalomethanes (THMs), aldehydes, acids, and ketones. THMs are suspected carcinogens and are regulated under current drinking water criteria. The use of chlorine may need to be minimized if THM precursor compounds are present in the influent water.

Chlorine dioxide: Chlorine dioxide is another effective disinfection agent but is a weaker oxidizer than chlorine. Chlorine dioxide is an unstable gas at standard conditions, explosive in air (at above 10 percent by volume), is dangerous to store in a compressed state, and should only be generated on site in an aqueous form in quantities to be used as soon as possible. Chlorine dioxide can be stored for short durations prior to use (EPA/625/4-89/023, 1990). Chlorine dioxide can be generated through several methods. Aqueous or solid sodium chlorite is reacted with either chlorine gas, sodium hypochlorite solution and a mineral acid, or just a mineral acid.

Some of the chlorine dioxide generation methods may result in the formation of free chlorine, which can form chlorite and chlorate ions. These ions have produced hematological effects in laboratory animals. A 1.0 mg/L level for chlorine dioxide has been recommended by EPA. One benefit of chlorine dioxide is that its use does not result in significant formation of THMs. Chlorine dioxide residuals are believed to last longer than free chlorine residuals because the chlorine dioxide has a lower oxidation potential and does not react as readily with organic compounds as chlorine.

Monochloramine: Monochloramine is a weak cysticide and virucide and generally is preferred as a secondary disinfectant since much higher concentrations and contact times are required than for chlorine, chlorine dioxide, or ozone. Monochloramine is produced by combining ammonia chlorine (as hypochlorite or hypochlorous acid) in water. Monochloramine can be produced on site or through the use of preformed solution brought on site. During the production of monochloramine, undesirable nitrogen trichloride (some times called trichloramine) may be produced. Controlling the reaction process is important in maximizing the generation of monochloramine and dichloramine, which are the disinfection agents.

Ozone: Ozone has been widely used in France, Germany, and Canada as a disinfecting agent to treat public water supplies. Chlorination is still the dominant means for disinfection in the United States, but concerns about treatment by-products (such as THMs that are suspected carcinogens) have created more interest in and use of ozone for water treatment. Ozone is only used as a primary disinfectant since it cannot be maintained as a residual in the treated water. A secondary disinfectant is required to protect the treated water.

Ozone is the strongest disinfectant, is highly reactive, and is a strong oxidizing agent. The use of ozone does not result in the formation of process by-products as would the use of chlorine or chlorine dioxide. However, if organic compounds are present in the raw influent water, ozone can partially oxidize these compounds and facilitate formation of other compounds. Therefore, care must be taken in identifying groundwater constituents and in selecting proper treatment means to minimize formation of undesirable by-products.

Ozone (O_3) gas can be generated on site through electrical discharges in the presence of oxygen. The generation of ozone is energy intensive since the very stable covalent bond of O_2 must be split.

Ultraviolet Radiation: Ultraviolet (UV) radiation (at a 254 nm wavelength) is used to disinfect bacteria and viruses but is ineffective against Giardia lamblia cysts. UV radiation passes through the microorganism's cellular walls, is absorbed, and prevents further replication of the cell. However, the target microorganisms must be sufficiently exposed to the radiation and killed so that they would not become active again. UV radiation produces no toxic residuals and requires a relatively short contact time. High suspended solids, color, turbidity, or high soluble organic compounds can reduce the effectiveness of the UV by absorbing the radiation. UV radiation is only used as a primary disinfectant, since no residuals are left in the finished water using this process. UV radiation is produced using special lamps such as the mercury arc lamp. An electric arc is passed through mercury vapor causing excitation and emission of UV energy at 254 nm.

Effectiveness - All disinfecting agents listed are capable of killing or inactivating viruses, bacteria, and cysts with varying degrees of effectiveness. Disinfection would be considered if installation of a new public water supply system is to be evaluated. Primary disinfectants such as chlorine, chlorine dioxide, ozone, and UV radiation can be used to produce finished water that would be safe for human consumption. Secondary disinfectants, including chlorine, chlorine dioxide, and monochloramine, are effective residuals in the finished water to prevent regrowth of harmful microorganisms. These chemicals have been used to address biological contaminants by water supply providers.

One benefit of using some of these disinfecting agents is that they are also oxidizers that are capable of degrading or destroying organic contaminants. Oxidation is discussed in Section 2.6.3.5.

Some of the disinfection agents may be used in combination to provide more complete destruction of harmful microorganisms. Effectiveness of these disinfection agents is dependent on the microorganisms present, other chemicals that may be present, presence of naturally occurring organic chemicals (such as organic acids) that may compete with or interfere in oxidation, pH, and temperature.

The use of any disinfection agent poses both positive and negative benefits. Use of any disinfection agent requires proper handling and application procedures to protect the health of workers and water supply users and to prevent any accidental releases to the environment.

Implementability - Disinfection is an implementable, conventional water treatment process that is widely used and is commercially available. Chlorination has been practiced since the turn of the century, is commonly used throughout the world, and is a standard procedure for water supply systems. Ozonation is also commonly practiced in several industrialized countries. Other methods are newer but produce less harmful residuals or by-products that pose threats to human health.

Chemicals such as chlorine and monochloramine are directly available from a number of vendors. These gases would need to be delivered to and stored at the site for use. Other disinfection agents, including chlorine dioxide, monochloramine, ozone, and UV radiation, could be generated on site using equipment that can be obtained from a variety of vendors.

In some situations, offgases such as ozone and chlorine would need to be controlled to prevent their release to the ambient air. The storage of chemicals that are strong oxidizers requires that site operations take industrial safety procedures into consideration and that protocols be establised to address accidental discharges and releases. Permits may be required if gases are used that may result in emissions to the ambient air. Measures may be required to reduce those emissions to acceptable levels. Permits would be required to operate the treatment systems as part of any water treatment facility.

The need for TSD facilities is not directly relevant to disinfection.

Cost - The capital and O&M costs for disinfection vary from low to high, depending on the specific method selected, the equipment required, and the source of water. The capital cost for chlorination systems is low, and associated O&M costs are low. Capital and O&M costs for application of chlorine dioxide are also relatively low. The costs for chloramination are comparable to those for chlorination; there are additional costs for liquid ammonia, however. Because of the equipment required, high degree of maintenance, and energy use, the capital and O&M costs for ozonation are expected to be high. UV radiation capital and O&M costs are anticipated to be high.

Conclusion - Disinfection is an effective and implementable treatment process for removing pathogens (if present) from groundwater used by residents near the Crossley Farm Site. However, the formation of undesirable residuals and intermediate products by some of the disinfection agents may pose potential health threats for residential users. However, these risks are not as significant as the threat posed by viruses, bacteria, or Giardia cysts in a water supply that could spread diseases and cause life-threatening illnesses. By regulation, disinfection is mandatory for all public water supplies. Disinfection is retained for further consideration.

2.6.3.4 Filtration

Filtration is a process that uses a porous medium to remove suspended solids from a liquid. It is valuable in water and wastewater treatment for removing suspended solids prior to primary treatment processes or for the final cleaning or polishing of treated effluent. It is effective in removing organic and inorganic contaminants (particularly metals) that are bound to suspended solids in groundwater, often reducing the need for further treatment of these contaminants.

Liquid filtration may be accomplished by numerous methods including screens, fibrous fabrics (paper or cloth), or beds of granular material. Flow through a filter can be encouraged by pressure on the inlet side or by drawing a vacuum on the filter outlet.

Effectiveness - Filtration is widely used to remove particulate metals and organic compounds that are bound to suspended solids from aqueous waste streams. Filtering systems can be staged to progressively remove smaller materials; many system variations have been designed to reduce clogging and provide easy maintenance. Conventional filtration is not effective in removing dissolved contaminants.

For treatment of groundwater at the Crossley Farm Site, filtration would effectively remove suspended solids to meet drinking water criteria and to ensure adequate treatment by processes sensitive to suspended solids presence. Filtration alone would not achieve overall drinking water criteria, but its use would facilitate proper operation of downstream treatment units and complete removal of suspended solids from the treated groundwater.

No adverse impacts to human health or the environment are likely to occur.

Implementability - Filtration is a readily implementable technology. Filtration systems are commercially available from a wide variety of manufacturers and can be readily ordered to almost any specification. Filter media will occasionally have to be replaced or regenerated, potentially resulting in the generation of sludges requiring specialized disposal.

Cost - Capital costs for filtration are low, as are O&M costs. O&M costs may increase slightly if high turbidity in the pumped groundwater requires additional filter maintenance.

Conclusion - Filtration is an effective and implementable technology to remove suspended solids from an aqueous waste stream. Filtration will be retained as a process option for groundwater treatment, for particulate metals removal, and as a safeguard for sensitive treatment processes such as activated carbon and UV/oxidation, when needed.

2.6.3.5 Oxidation

Oxidation is a process by which the oxidation state of a compound is raised to change the chemical form of the compound to render it less toxic or change its solubility or stability. Several oxidation agents have been used singly or in combination to degrade or destroy organic chemicals in drinking water, including ozone, chlorine, chlorine dioxide, ultraviolet radiation, hydrogen peroxide, and permanganate. Theoretically, organic compounds can be completely degraded to carbon dioxide and water. However, complete oxidation is not possible in all instances, and daughter products are formed that are more resistant to oxidation processes. In certain situations, dissolved organic compounds may be converted into insoluble suspended matter and can be removed through coagulation or filtration.

Chemical oxidation is commonly used in wastewater treatment to remove reduced, soluble forms of metals by employing oxidizing agents such as oxygen, chlorine, and permanganate. Groundwater pumping and treatment systems have also used these oxidizing agents to reduce or remove metals to meet allowable effluent standards.

Effectiveness - All oxidizing agents listed above are commercially available through a variety of vendors and have been used for water and wastewater treatment. All the oxidizing agents have varying degrees of effectiveness in degrading the contaminants of concern present in site groundwater. One benefit of using some of these oxidizing agents is that they also have a disinfecting effect and would kill or inactivate pathogens that are harmful to humans. Disinfection is discussed in Section 2.6.3.3.

Some of the oxidizing agents may be used in combination to provide more complete degradation or destruction of organic contaminants. However, treatment residuals and intermediate by-products may be toxic and require additional treatment. The effectiveness of these oxidizing agents is dependent on the chemicals to be treated, the presence of naturally occurring organic chemicals (such as organic acids) that may compete with or interfere in oxidation, pH, temperature, dissolved minerals, and how amenable the chemicals are to oxidation.

Implementability - Chemical oxidation is an implementable, conventional water treatment process that is widely used and commercially available. Ozone generators can provide an ample supply of ozone at the site for use. Hydrogen peroxide is available through several vendors and would need to be transported to the site and would require storage. Gases such as oxygen and chlorine would need to be delivered to and stored at the site for use. The storage of oxidizing chemicals requires that site operations take industrial safety procedures into consideration and that protocols for addressing accidental discharge and releases be made. Permits may be required if gases are used that may result in emissions to the ambient air. Measures may be required to reduce those emissions to acceptable levels.

Cost - The capital and O&M costs for chemical oxidation vary from low to high, depending on the specific chemical selected, the equipment required, and associated safeguard mechanisms.

Conclusion - Chemical oxidation is an effective and implementable treatment process for site-specific groundwater contaminants. However, the formation of undesirable residuals and intermediate oxidation products may pose a problem in trying to produce a finished water suitable for drinking water use. Chemical oxidation is retained for further consideration.

2.6.3.6 Precipitation and Coagulation-Flocculation

Precipitation and coagulation-flocculation are closely related treatment processes that facilitate removing dissolved or particulate metals from aqueous waste streams. Precipitation is a physicochemical process by which dissolved metals are transformed to insoluble salts through the addition of chemical reagents. Precipitation is a viable technique for the removal or reduction of dissolved metals from the process water but is not effective in removing dissolved organic contaminants.

Coagulation-flocculation is a process in which chemical reagents that act to neutralize surface charges on suspended solids are added to the waste stream to promote the agglomeration of small, unsettleable, suspended particles into larger, more settleable particles. All coagulants are capable of removing some organic compounds, especially those with large molecular structures. Coagulants would have to be selected to match the affinities specific to the contaminants of concern (EPA/625/4-89/023). Coagulants are available that reduce organics such as total organic carbon (TOC), color (usually attributable to humic or fulvic acids), turbidity, trihalomethane (THM) precursors, and microbiological organisms (bacteria and viruses) (ASCE/AWWA, 1990).

These processes are often used in combination to facilitate complete removal of dissolved and suspended metals from aqueous waste streams. In a typical treatment system, precipitants and flocculants are added to the waste stream in a rapid mixing tank. The water then flows to a flocculation chamber where mixing at lower velocities and for longer periods facilitates the formation of large, readily settleable floc particles.

Common precipitation methods involve removing dissolved metals through formation of hydroxides by lime (CaO) or caustic soda addition; formation of sulfides by sodium hydrosulfide, ferrous sulfide, or hydrogen sulfide addition; or formation of metal-iron compounds by adding ferric chloride or ferric sulfate. Metal hydroxides have a tendency to redissolve outside an optimum pH range; however, they are much easier to handle, safer, and less expensive to generate than sulfides. Sulfide precipitation, however, generally allows for significantly lower treated effluent concentrations. Coprecipitation techniques are also capable of attaining low effluent concentrations. Proprietary processes, such as Sulfex® and Unipure®

employ ferrous iron compounds that can simultaneously result in reduction and precipitation at neutral pH conditions.

Many precipitants such as lime and alum act dually as flocculants, facilitating the precipitation of dissolved metals and the agglomeration of the suspended precipitates into large, settleable particles. However, other precipitants such as sulfide ions form very fine, relatively stable colloidal particles that require the addition of flocculating agents to facilitate settling. Commonly used flocculants include alum, lime, various iron salts (ferric sulfate), and cationic organic polymers.

Effectiveness - Precipitation and coagulation-flocculation are well-established and effective processes used to remove dissolved metals and suspended solids from water and wastewater. Coagulation-flocculation has been employed as an effective pretreatment step in removing organic compounds from water and wastewater. For the site-specific contaminants of concern, coagulation may be effective in causing the organic compounds to agglomerate and be removed from the process water in subsequent treatment steps (such as filtration, sedimentation, or clarification). No impact to human health or the environment is anticipated through the implementation of either precipitation or coagulation-flocculation.

Treatment of groundwater using precipitation or coagulation-flocculation is capable of handling the influent flow rate based on the projected water usage by affected residences. These processes are only suitable for a large treatment plant but not for household use.

Sludge that would be produced may require further treatment prior to disposal, based on results of waste characterization testing to determine whether the material is considered hazardous.

Implementability - These technologies are widely used in groundwater treatment and are readily available commercially, although proprietary processes are only available through a few vendors. Key process parameters include reagent dosages, pH adjustment requirements, temperature, influent groundwater characteristics, and sludge handling requirements. Jar tests and pilot tests are required to determine the most effective chemicals for site-specific contaminants and to assess chemical doses that are efficient and economical.

Precipitation and coagulation-flocculation are non-destructive treatment processes that generate sludges requiring special handling. The sludges may need to be properly disposed in a permitted facility. As with filtration, excessive suspended solids in the raw water will increase the volume of sludge generated and may necessitate added maintenance.

Cost - The capital costs are expected to be moderate, as are O&M costs, due to chemical addition and sludge handling/disposal requirements.

Conclusion - Precipitation and coagulation-flocculation will be retained as potential process options to remove dissolved metals and organics from site groundwater.

2.6.3.7 Reverse Osmosis

Reverse osmosis is a filtration technology that uses a semi-permeable barrier that will allow the passage of only certain components of a solution. The membrane is permeable to water but impermeable to most dissolved substances, both organic and inorganic. The driving force is an applied-pressure gradient to overcome the osmotic pressure of the contaminated solution. Relatively clean water is produced on the down-flow side of the membrane; the rejected organic and inorganic compounds remain on the up-flow side as a concentrated waste stream (a "brine") that requires further treatment or disposal.

Reverse osmosis systems are operationally sensitive. Therefore, close monitoring of the temperature, pressure, and pH of the contaminated solution is necessary. In addition, the chemical and physical structure of the membrane must be closely monitored because the contaminants in the solution may react with and reduce its integrity.

Effectiveness - Reverse osmosis is effective in concentrating dilute solutions of many inorganic and some organic solutes. Reverse osmosis may reduce excess dissolved solids, reduce or remove many metals, and produce almost turbidity-free water. As such, reverse osmosis may be applicable and effective as a pre-treatment for controlling lead levels in certain residential wells. The primary application of reverse osmosis is desalinating brackish water for potable use. However, reverse osmosis may not be appropriate for the primary treatment of groundwater in the Crossley Farm Site vicinity because the primary contaminants are chlorinated organics that may degrade the reverse osmosis unit membranes. The reject stream would consist of relatively concentrated organics that would require additional treatment or off-site disposal.

Implementability - Although equipment and resources are specialized, the reverse osmosis process is commercially available. Reverse osmosis membranes, in general, are subject to deterioration and may require periodic replacement. Membranes have life expectancies of about 2 years. Membrane deterioration and replacement frequency may be accelerated by the high concentrations of chlorinated compounds in site groundwater. Pretreatment may be required to optimize pH.

Cost - Capital and O&M costs of reverse osmosis are high.

Conclusion - Reverse osmosis is eliminated from further consideration as the primary treatment for supply systems because of effectiveness concerns and the availability of other more effective and economical technologies for addressing VOCs (i.e., air stripping, carbon adsorption). However, reverse osmosis is retained for further consideration as a pre-treatment because of its ability to remove lead ions from drinking water for point-of-entry or point-of-use treatment systems.

2.6.3.8 Ion Exchange

Ion exchange is a process in which ionic substances are removed from the aqueous phase through adsorption of contaminant ions onto a resin exchange medium. The toxic ions are exchanged with relatively harmless ions held by the ion exchange material. The resins are insoluble solids containing fixed cations or anions capable of reversible exchange with mobile ions of the same charge in solutions with which they are brought into contact. Ion exchange is typically used by a public water supply to remove hardness and nitrates. Sodium chloride is typically used in ion exchange units as the exchange medium because of its low cost, but its use may result in high sodium levels in the finished water. The ion exchange resins will eventually be exhausted and must be regenerated. The regeneration waste contains a high concentration of contaminants and must be further treated or disposed. The ion exchange process is relatively insensitive to flow rate.

Activated alumina (aluminum oxide) is an ion exchange medium that is typically used to remove excess fluoride from public water supplies. Although activated alumina can be used to remove lead ions from water supplies, less costly processes such as pH adjustment are employed by public water supplies to control lead levels (which typically result from leaching of lead solder or pipes). However, activated alumina has been effectively used for lead removal in point-of-entry or point-of-use treatment systems.

Effectiveness - Ion exchange is effective for removing soluble metals and anions such as halides, sulfates, and nitrates. Because of resin capacity and regeneration restrictions, ion exchange is most applicable for treating dilute waste streams. Influent suspended solids must be very low to minimize fouling or plugging of the resin bed. Some organics, especially aromatics, can be irreversibly adsorbed by the resin, resulting in decreased capacity. Ion exchange may effectively remove dissolved metal ions from the ground or surface water. However, the presence of suspended solids and organics in the source water may cause fouling of the ion exchange resins, thereby decreasing cation exchange capacity. Waters with high hardness will contain ions that would compete with other cations for sites on the exchange medium.

Sophisticated controls are required to detect breakthrough of contaminants when the capacity of the resin is close to being exceeded. The regenerant stream that is produced would require additional treatment prior to disposal.

Implementability - Ion exchange would be implementable. Many vendors are available to provide ion exchange units.

Cost - Capital costs for public water supply applications are moderate and O&M costs range from moderate to high, depending on the frequency of regeneration required, which is a function of influent contaminant concentrations. Capital and O&M costs for ion exchange point-of-entry systems are relatively low.

Conclusion - Ion exchange has been removed from further consideration for public water supply systems since more cost-effective treatment processes are readily available to remove metal ions or to control lead leaching from piping. However, ion exchange (specifically activated alumina) is retained for further consideration because of its ability to remove lead ions from drinking water for point-of-entry or point-of-use treatment systems.

2.6.4 New Water Supply

Another response action is the provision of a new water supply for the affected residences. Two options are available that do not rely on the aquifer underlying the Crossley Farms Site as a water source: delivered bulk water and a new supply line. Two options are available that do rely on extracting groundwater from the aquifer underlying the site: installation of new private water supply wells and installation of community water supply wells. Each option is discussed and evaluated in the following narrative.

2.6.4.1 Delivered Water

Under this scenario, potable water (either bottled or in bulk) would be provided to residences whose water supplies have been deemed unfit for consumption because either MCLs and/or risk-based concentrations have been exceeded. Bottled water would be delivered to residences where the principal exposure to contaminants is through ingestion. Bulk water would be necessary at those residences where the contaminant concentrations are sufficiently high to also cause excess risks through the dermal and/or inhalation exposure pathways. Storage tanks would have to be installed in each residential property and potable water would be delivered on a scheduled basis.

Effectiveness - The delivered-water option would achieve the RAO since previously affected residences would no longer use contaminated groundwater. Human health risks associated with exposure to carcinogenic and non-carcinogenic contaminants in groundwater would be eliminated.

Implementability - The delivered-water option is readily implementable. For bottled water, a typical household of four and a consumption (ingestion) rate of 5 gallons per person every 2 weeks, individual bottles or a small capacity storage tank would be needed. The tank would be replenished weekly. A number of bottled-water supply companies are available to provide the necessary services. For those residences where bulk water would be required (assuming a total daily consumption rate of 125 gallons per person), larger storage tanks and multiple deliveries per week would be required. Several companies or sources are available to provide the necessary services. The water storage tanks would have to be installed in locations that are protected from extremes in weather, such as freezing or heat, that may cause water usage problems. Storage tanks would have to be joined with each household's plumbing system, although this would not be difficult. Periodic maintenance may be required to avoid bacterial contamination of the stored water.

Cost - The capital cost of installing individual storage tanks would be low. O&M costs would be moderate since each affected residence would require replenishing of its supply on a scheduled basis, and maintenance would be necessary to abate growth of microbiological organisms in the storage tanks. The overall cost to provide delivered water is low to moderate.

Since contaminants remain in groundwater and no active treatment actions would be taken, 5-year reviews of site status and groundwater conditions would be required. The costs for the 5-year reviews are anticipated to be low.

Conclusion - This option would be effective in preventing exposure to contaminated well or spring water through ingestion. The option can be easily implemented and expanded to additional households that may be affected in the future. The delivered-water technology is retained for further consideration.

2.6.4.2 Water Line

Under this scenario, potable water would be provided to residences whose water supplies have been contaminated. A water supply line would be installed from an existing municipal water supply and each affected residential property would be tied into the new service line. No further exposure to contaminated groundwater would occur.

Effectiveness - The water-line option would achieve the RAO since previously affected residences would no longer use contaminated groundwater. Human health risks associated with exposure to carcinogenic and non-carcinogenic contaminants in groundwater would be eliminated.

Adverse impacts to humans are not anticipated through installation of a water line. Some short-term impacts to the environment may occur during construction.

Implementability - The supply-line option is implementable but less so than the delivered-water option. Extensive excavation would be required to install a supply line at least 3 feet below ground surface (for protection from freezing), and extensive lengths of piping may be required to tie into the closest nearby municipal system because of the distance. Implementation of this option is highly dependent on many factors, including the proximity of a municipal water supply, quality of water produced by the municipal supply, capacity of the system, local geologic and subsurface conditions, terrain, need for booster pumping (to transmit water across long distances or changes in elevation), and availability of utilities. The institutional implementability of this option would require consideration of the ease of acquiring property easements, willingness of the municipal supply to enlarge its service, and willingness of the affected residents to be connected to a public water supply, permit requirements, and the long-term administration of the distribution system and associated costs.

For the 29 households that have been affected to date, an average water use of 125 gallons per capita per day is anticipated.

Consideration of the availability of TSD facilities is only indirect. If the existing municipal system uses and disposes of filters, spent carbon, and sludges, then additional disposal or regeneration capacity may be required.

Cost - The capital costs for installing a new water line and multiple service lines would be moderate to high, depending on topographic and subsurface features encountered during construction. O&M costs are anticipated to be low.

Conclusion - This option would meet the RAO and would protect human health by providing an uncontaminated source of potable water for the affected community. Capital costs may range from moderate to high, and O&M cost would likely be low. There are both technical and institutional considerations that may pose some difficulties. However, this option is viable and is retained for further consideration.

2.6.4.3 New Private Supply Wells

Under this scenario, new private supply wells would be installed on the properties where current water supplies have been contaminated. Deeper wells would be drilled to intersect bedrock fractures not connected to fractures that are currently affected by site contaminants.

Effectiveness - A new supply well screened in an uncontaminated bedrock fracture would meet the RAO. However, available site data indicate that aquifer contamination extends to great depths and unaffected bedrock fractures in the vicinity of the site may not be present. In addition, the site geology (bedrock fractures exposed at ground surface), the disposal history at the site, and the elevated concentrations of TCE and PCE indicate the potential presence of non-aqueous phase liquids (NAPLs) in the bedrock aquifer. These NAPLs would be continuing sources of groundwater contamination to the residences. It is likely that point-of-entry treatment would be required to remove the contaminants of concern.

Implementability - The installation of new supply wells is readily implementable. Numerous drilling companies with appropriate personnel and equipment are available to install new supply wells. Connection of the supply wells to existing residential plumbing would pose no technical problems.

Consideration of the availability of TSD facilities does not apply to this option. If point-of-entry treatment is required, then spent materials such as filters will need to be disposed, possibly in a solid waste or municipal landfill. However, a TSD facility would not be required.

Cost - The cost of new well installation is expected to be moderate. O&M would also be moderate since long-term monitoring would be required to assess the quality of water.

Conclusion - Because of the uncertainties of this option's effectiveness, the potential presence of NAPLs, and the present uncertainty as to whether uncontaminated bedrock fractures can even be located within the proximity of the Crossley Farms Site, this option will not be retained for further consideration.

2.6.4.4 New Community Supply Wells

Under this scenario, new community supply wells and water distribution lines would be installed, and affected residences would be tied into the distribution lines and provided with potable water. This option would necessitate finding a location for the installation of a new well field and probably a new water treatment facility.

Effectiveness - This option would achieve the RAO since a public water supply would provide potable water that meets all federal and state drinking water criteria. Residents with contaminated wells or springs would no longer be exposed to groundwater contaminants.

A review of the background data (as described in Section 2.6.4.3) indicates the potential presence of NAPLs in the bedrock aquifer that would be continuing sources of groundwater contamination and could be mobilized through pumping of wells. Therefore, the new well field would be placed to ensure that the existing groundwater situation is not exacerbated. The well locations would also have to be compatible or not interfere with any groundwater remediation system installed to treat the contaminated groundwater. Even with these precautions, treatment of extracted groundwater would probably be necessary to produce a finished water that meets drinking water criteria. This option would be more effective than new individual supply wells or point-of-entry treatment since the water treatment process and quality are monitored and adjusted on a consistent basis.

No adverse impacts to humans are anticipated during construction or implementation. Short-term impacts to the environment may occur during drilling and excavation activities.

Implementability - This option is technically implementable since the equipment and resources necessary to install large-capacity supply wells and construct water treatment facilities are widely available. The types of groundwater contaminants can be addressed through a variety of treatment processes, and the finished water would be of drinking water quality.

Since the area of interest is sparsely populated, selection of a location for the wells and treatment facility should not pose any technical challenges. The actual location selected would require potential access agreements, easements, or purchase of properties. Excavation and installation of the new distribution lines may require permits. Operation of a treatment plant would require trained operators and a responsible agency to administer the system.

Consideration of the availability of TSD facilities and services and the need for permits will be dependent on the treatment processes selected and the specific types of residues and by-products generated.

Cost - The capital cost for construction is anticipated to be high since new wells, distribution and service lines, and treatment facility would be required. O&M costs are anticipated to be moderate to high, depending on the extent of treatment processes required.

Conclusion - While this option poses relatively high costs, it can more effectively provide a potable supply that consistently meets drinking water criteria than other options such as point-of-entry treatment or new residential supply wells. This option is retained for further consideration.

2.7 EVALUATION SUMMARY AND SELECTION OF TECHNOLOGIES AND PROCESS OPTIONS

The evaluations of technologies and process options, based on effectiveness, implementability, and cost, are summarized in Table 2-9. The overall conclusions of the technologies and process options evaluations are also identified.

The technologies and process options for groundwater that have been retained for further consideration in this report are as follows:

- No Action
- Institutional Controls
  - Local ordinances
  - Groundwater monitoring

- Physical Treatment
  - Air stripping
  - Carbon adsorption
  - Filtration
  - Chemical Treatment
  - Oxidation
  - Disinfection
  - Precipitation and coagulation-flocculation

- New Water Supply
  - Delivered water
  - Supply line
  - New community supply wells

TABLE 2-9
EVALUATION OF TECHNOLOGIES AND PROCESS OPTIONS FOR CONTAMINATED WATER SUPPLIES
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	EFFECTIVENESS	IMPLEMENTABILITY	COST	RETAIN/ ELIMINATE
No Action	No Action	No Action	Does not achieve remedial action objectives.	Implementable.	Capital: None O&M: None	Retain per NCP
Limited Action	Institutional Controls	Deed Restrictions and Notices	Does not achieve remedial action objectives. Effectiveness depends on future enforcement and is likely to be low. Does not reduce contamination.	Implementation may require legal action by state or local officials.	Capital: Low O&M: Low	Eliminated
		Local Ordinances	May provide some protection of human health if new-wells installation or groundwater use is regulated and enforced.	May be difficult to implement since some disruption of residences is anticipated. Enforcement may be difficult.	Capital: Low O&M: Low	Retain for limited use
		Access Restrictions	Would prevent access to contaminated springs but would not achieve RAO or address contaminated water supplies.	Easily implemented, and equipment and resources are readily available. Access agreements to private properties are required.	Capital: Low O&M: Low	Retain for limited use
	Monitoring	Groundwater Monitoring	Would not achieve RAO and does not reduce contamination. Can observe drinking water quality and assess potential groundwater contaminant migration.	Readily implementable, and equipment and resources are readily available. Access agreements may be required for installation of new monitoring wells on private property.	Capital: Low O&M: Low to moderate	Retain
Treatment	Physical	Air Stripping	Effective for removing most site VOCs from groundwater; capable of meeting remediation goals for most VOCs. Demonstrated technology. Off-gas controls may be required.	Readily implementable using commercially available equipment and resources. Permits may be required for air emissions. May require off-site disposal of treatment residuals.	Capital: Low O&M: Moderate	Retain
		Carbon Adsorption	Effective for nearly complete removal of VOCs from site groundwater. Demonstrated technology. Would achieve RAO.	Readily implementable using commercially available equipment and resources. Will require regeneration or disposal of spent carbon.	Capital: Low O&M: Low to High	Retain

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TABLE 2-9
EVALUATION OF TECHNOLOGIES AND PROCESS OPTIONS FOR CONTAMINATED WATER SUPPLIES
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	EFFECTIVENESS	IMPLEMENTABILTIY	COST	RETAIN/ ELIMINATE
Treatment (continued)		Filtration	Effective process for removal of suspended solids, with adsorbed contaminants, from groundwater. Demonstrated technology.	Readily implementable using commercially available equipment and resources. Will require disposal of spent filters or filtrate.	Capital: Low O&M: Low	Retain
		Ion Exchange	Would reduce or remove ions from groundwater. Not selective in which ions are captured. Other, more cost-effective methods are available to control lead levels in public water supplies. Would be appropriate for lead removal in point-of-entry applications, using activated alumina.	Implementable. Specialized equipment and resources are required but are commercially available. Will require disposal of spent ion exchange materials.	<u>Public system</u> Capital: Medium to high. O&M: Medium <u>Point of entry</u> Capital: Low O&M: Low	Eliminate for public systems. Retain for point-of-entry systems.
		Reverse Osmosis	Would not achieve RAO. May reduce or remove many organics and metals from groundwater. Chlorinated VOCs in site groundwater may degrade the reverse osmosis unit membranes. Demonstrated technology primarily for metals.	Implementable. Specialized equipment and resources are required but are commercially available. Will require disposal of filtrate.	Capital: Low O&M: Moderate	Eliminate as primary treatment. Retain for lead removal (if needed) for point-of-entry systems.

AR300254

TABLE 2-9
EVALUATION OF TECHNOLOGIES AND PROCESS OPTIONS FOR CONTAMINATED WATER SUPPLIES
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	EFFECTIVENESS	IMPLEMENTABILITY	COST	RETAIN/ ELIMINATE
Treatment (continued)	Chemical	Disinfection	Would facilitate achieving RAO. Effective in killing or inactivating pathogens. Some disinfectants are strong oxidizers and will also degrade or destroy some organic contaminants. Demonstrated technologies.	Readily implementable using commercially available equipment and resources. A variety of disinfecting methods are available, some demonstrated, some newer. Air emissions control may be required.	Capital: Low to high O&M: Low to high, depending on option chosen	Retain
		Oxidation	Can achieve RAO. Effective process for facilitating degradation or destruction of groundwater VOCs. Demonstrated technology.	Readily implementable using commercially available equipment and resources.	Capital: Low to high O&M: Low to high, depending on option chosen	Retain
		Precipitation Coagulation/ Flocculation/	Can facilitate achieving RAO. Effective for removal of dissolved and particulate metals and suspended solids from site groundwater. Sludge produced may require treatment prior to disposal. Demonstrated technologies.	Readily implementable using commercially available equipment and resources. Off-site disposal of sludges may be required.	Capital: Moderate O&M: Moderate	Retain

AR300255

TABLE 2-9
EVALUATION OF TECHNOLOGIES AND PROCESS OPTIONS FOR CONTAMINATED WATER SUPPLIES
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	EFFECTIVENESS	IMPLEMENTABILITY	COST	RETAIN/ ELIMINATE
New Water Supply	New Water Supply	Delivered Water	Would achieve RAO. No further exposures. Only an interim solution. Would not reduce groundwater contamination.	Easily implementable from a variety of vendors.	Capital: Low O&M: Low	Retain
		Water Line	Would achieve RAO. No further exposures anticipated. Would not reduce groundwater contamination.	Will require connection to nearby municipal water supply. Capacity may be an issue. Distance and elevation difference may require significant pumping. Willingness of residents to tie into service unknown. Administration may be difficult.	Capital: Moderate O&M: Low	Retain
		New Private Supply Wells	Would probably not achieve RAO. Would probably need point-of-use treatment. Difficult to control water quality. Would require monitoring.	Easily implementable; equipment and resources are readily available. Permits not required.	Capital: Moderate O&M: Moderate	Eliminate
		New Community Supply Wells	Would achieve RAO. No further exposures, with properly operated plant. Water quality can be monitored and controlled.	Implementable; equipment and resources are available. Operating permits would be required. Selection of new well field treatment plant location required. Operation and administration of system would be required.	Capital: High O&M: Moderate to high	Retain

AR300256

3

3.0 DEVELOPMENT OF REMEDIAL ACTION ALTERNATIVES

This section presents the rationale for developing and screening remedial action alternatives and describes the assembled drinking water supplies alternatives.

3.1 RATIONALE FOR DEVELOPMENT OF ALTERNATIVES

The alternatives were developed in accordance with the National Contingency Plan (NCP; 40 CFR 300.430) and the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA Interim Final, 1988). The NCP encourages development of alternatives that favor treatment technologies to address principal threats and engineering controls to address relatively low, long-term threats. Additionally, the NCP suggests development of a range of treatment alternatives, one or more engineering control alternatives (e.g., containment), one or more innovative treatment alternatives, and the baseline no-action alternative. For this FFS, the use of engineering controls (such as hydraulic containment, sheet piles, etc) cannot be considered until more site-specific geologic and hydrogeologic information is developed.

Water supply alternatives were developed by combining the various general response actions retained for further evaluation in Section 2.4. The general response actions were combined to form a range of alternatives using different technology types and different remediation goals. Section 2.3.2 discusses the general response actions potentially applicable to alternate water supplies: no action, institutional controls, treatment, and new water supply. All these general response actions were retained for further consideration in the technologies screening (Section 2.4). All the developed treatment alternatives are anticipated to be effective in addressing the contaminated groundwater.

Proposed Remedial Action

The alternatives were developed under the premise that the provision of an alternate water supply can be either an interim or permanent action to prevent exposure by residents to contaminated water supplies. The nature and extent of groundwater contamination and the nature of groundwater flow in the hydrogeologically complex aquifers underlying the site and adjacent areas will need to be investigated fully before final groundwater response measures can be formulated. It is anticipated that an ongoing RI/FS will characterize site contamination and develop appropriate source control and groundwater response actions while this action is implemented. The remedial actions proposed in this FFS for water supplies are anticipated to be consistent with the final site remedy.

Contaminants to be Addressed

As discussed in the summary of the preliminary risk assessment (Section 1.5), chlorinated VOCs are estimated to pose the most carcinogenic risks to residential users of contaminated groundwater. The VOCs include trichloroethene (TCE) (the major contributor of carcinogenic risk), tetrachloroethene (PCE), chloromethane, methylene chloride, bromodichloromethane, chloroform, carbon tetrachloride, and 1,1-dichloroethene.

The preliminary risk assessment also determined that TCE poses the most non-carcinogenic risks (Hazard Quotient exceeding 1.0). Other contributors of non-carcinogenic risk include manganese, PCE, cis-1,2-dichloroethene, and trichlorofluoromethane.

A review of the residential well and spring sampling results identified several organic compounds and one inorganic compound (lead) that exceeded federal and state primary drinking water criteria. The organic compounds included TCE, bromodichloromethane, chloroform, cis- and trans-1,2-dichloroethene, PCE, and 1,1,2-trichloroethane.

Past sampling results indicate that contaminant concentrations vary from residence to residence and also vary with time. There is currently insufficient information to determine contaminant distribution patterns or estimate whether an individual well's contaminant levels will increase or diminish over time. Groundwater flow and contaminant plume migration for the underlying fractured bedrock aquifer may be difficult to characterize with the limited available data. Therefore, the alternatives were conservatively developed to address all detected contaminants and to be effective versus the unlikely case that any particular well contains all detected contaminants at their maximum observed concentrations.

The remedial alternatives were assembled to address the potential exposures to carcinogenic and non-carcinogenic contaminants and to contaminants present at levels above the MCLs. Due to the uncertainties discussed above, the FFS applies each alternative equally to all affected users, rather than customizing treatment systems for each particular well.

Alternate Water Supply Quality Goal

The goal of the alternate water supplies under this FFS is to provide potable water that does not contain contaminants in excess of the federal and state primary drinking water criteria (the MCLs) and would not result in total carcinogenic risk of 1E-4 or a Hazard Index greater than 1.0. With the exception of the no-action alternative, all alternatives were assembled to address this goal.

Potential Exposures to Contaminated Water Supplies

The preliminary risk assessment identified ingestion as the primary exposure route that resulted in greatest risk, followed by inhalation and dermal contact. The remedial alternatives were assembled to mitigate, reduce, or eliminate the exposure pathways, thereby minimizing risks posed by the use of contaminated groundwater.

3.2 ALTERNATIVES DESCRIPTIONS

Detailed descriptions of the alternate water supply alternatives are provided in this section. Figures 3-1 through 3-6 depict graphically the key components for each alternative.

3.2.1 Alternative 1: No Action

This alternative is developed and retained as a baseline scenario to which the other alternatives may be compared, as required by the NCP. The only activity that would occur under the no-action alternative is long-term monitoring and a review of site conditions and risks every 5 years. Under this alternative, residents would continue to be exposed to VOC and metals contaminants in the groundwater through their private drinking water supplies.

Long-Term Monitoring - Because no actions would be implemented under this alternative, residents that rely on contaminated groundwater for their drinking water supplies would remain at risk. Therefore, groundwater from affected residential wells and monitoring wells would be sampled and analyzed to assess the quality of water that is being used and the status of the bedrock groundwater contaminant plume. It is anticipated that approximately 50 residential and monitoring wells would be sampled and analyzed annually for VOCs and metals.

Five-Year Reviews - Every 5 years, the groundwater and residential wells monitoring data would be reviewed to assess the status of the site source areas and their condition, status of groundwater contamination, changes in potential risks, and whether imminent hazards are posed by site contaminants.

3.2.2 Alternative 2: Delivered Water

Under this alternative, bottled or bulk water would be provided to each residence that has a water supply contaminated in excess of MCLs or risk-based action levels. Provision of delivered water would reduce or

FIGURE 3-1
KEY COMPONENTS OF ALTERNATIVE 1 - NO ACTION
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, BERKS COUNTY, PA

Long-term Monitoring

- Annually sample 55 groundwater locations (private residential water wells, springs, and monitoring wells)
- Analyze collected samples for VOCs and metals
- Compile and document results

Five-Year Reviews

- Review collected analytical results
- Assess contaminant migration status
- Identify whether additional residential wells are at risk
- Determine whether remedial actions are needed

FIGURE 3-2
KEY COMPONENTS OF ALTERNATIVE 2 - DELIVERED WATER
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, BERKS COUNTY, PA

IMPLEMENTATION PERIOD	POST-IMPLEMENTATION PERIOD
Storage Tanks Installation • Disconnect well pumps • Install polyethylene tanks inside or outside of affected homes • Install valves and filler necks • Install well pumps in PE tanks • Test and connect **Bottled Water Hardware Provision** • Provide room temperature stands to designated residences	**Long-term Deliveries** • Periodically replenish bottled or bulk water **Institutional Controls** • Local health or construction ordinances to prohibit use of contaminated, untreated ground or spring water for potable use (drinking, growing vegetables, etc.) • Deed restrictions to prevent use of contaminated private wells at affected properties **Long-term Monitoring** • Semi-annual sampling of 55 groundwater locations (private residential water wells, springs, and monitoring wells) • Analyze collected samples for VOCs and metals • Compile and document results **Five-Year Reviews** • Review collected analytical results • Assess contaminant migration status • Identify whether additional residential wells are at risk • Determine whether further remedial actions are needed

FIGURE 3-3
KEY COMPONENTS OF ALTERNATIVE 3 - POINT-OF-ENTRY TREATMENT
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, BERKS COUNTY, PA

IMPLEMENTATION PERIOD	POST-IMPLEMENTATION PERIOD
<u>Treatment Systems Installation</u> • Assess chemical reduction requirements for each affected residence • Install pre-filter, activated carbon, and ultra-violet disinfection unit • As needed, install pH adjustment units and manganese removal unit (softener or ion exchange resin) • Install valves and sampling ports • Connect to plumbing system • Test and adjust	<u>Long-term System O&M</u> • Replace activated carbon, UV bulb, and spent softening agents. <u>Institutional Controls</u> • Local health or construction ordinances to prohibit use of contaminated, untreated ground or spring water for potable use (drinking, growing vegetables, etc.) • Deed restrictions to prevent use of contaminated private wells at affected properties <u>Long-term Monitoring</u> • Semi-annual sampling of 55 groundwater locations (private residential water wells, springs, and monitoring wells) • Analyze collected samples for VOCs and metals • Compile and document results <u>Five-Year Reviews</u> • Review collected analytical results • Assess contaminant migration status • Identify whether additional residential wells are at risk • Determine whether further remedial actions are needed

NOTES

1. ACTUAL SYSTEM CONFIGURATION DEPENDENT ON INDIVIDUAL RESIDENT'S CONTAMINATION PROBLEMS AND DEGREE OF CONTAMINATION REDUCTION REQUIRED TO MEET PRIMARY DRINKING WATER CRITERIA.
2. pH ADJUSTMENT AND MANGANESE REMOVAL (WATER SOFTENER) UNITS ADDED, AS NEEDED.

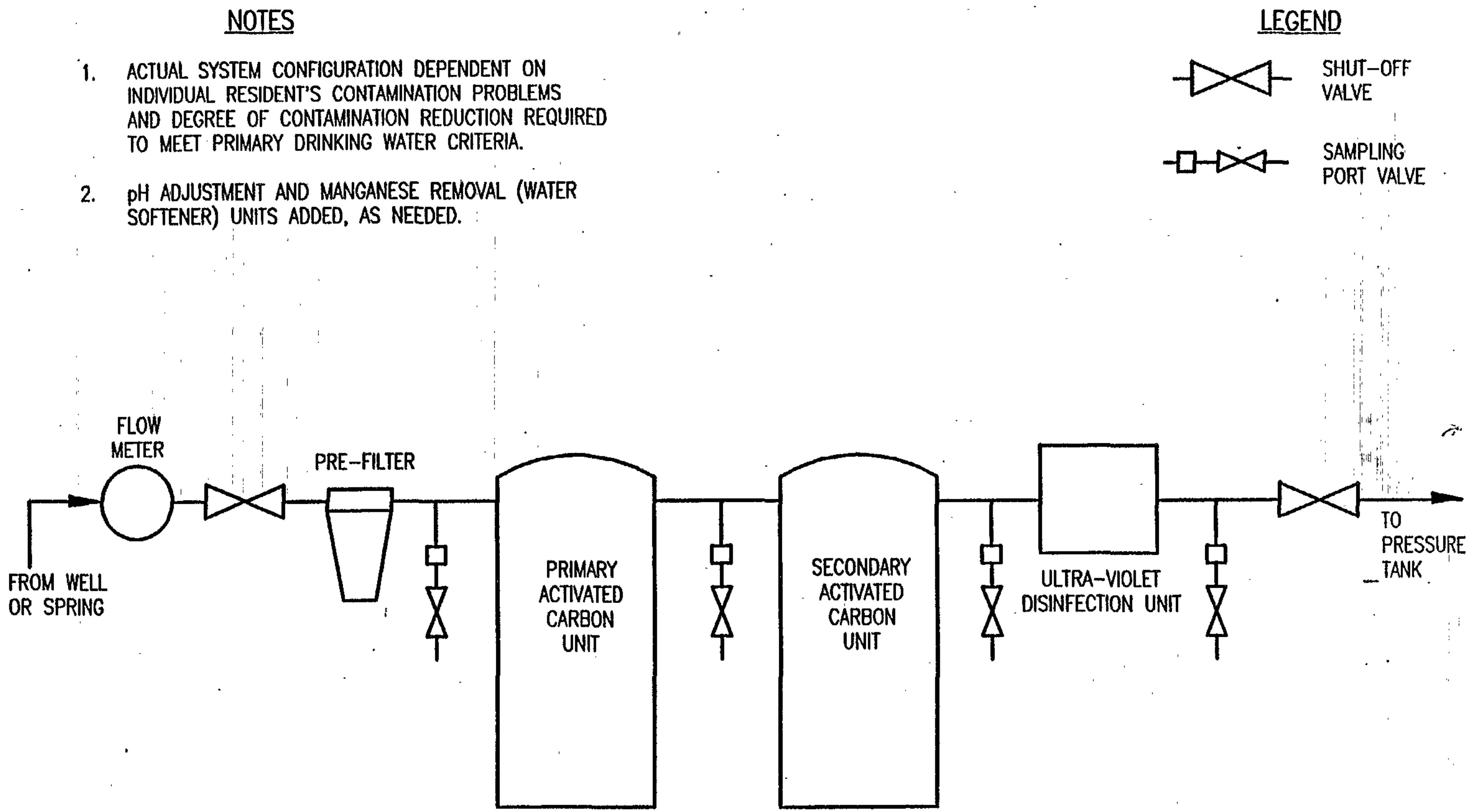

FIGURE 3-4

ALTERNATIVE 3
CONCEPTUAL POINT-OF-ENTRY TREATMENT SYSTEM
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, PENNSYLVANIA

Halliburton NUS CORPORATION

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FIGURE 3-5
KEY COMPONENTS OF ALTERNATIVE 4 - NEW SUPPLY LINE
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, BERKS COUNTY, PA

IMPLEMENTATION PERIOD	POST-IMPLEMENTATION PERIOD
<u>Distribution System Design</u> • Engineering assessment of water use and demand • Evaluate topography and hydraulic head pumping requirements • Design water distribution and booster pumping system <u>Distribution System Installation</u> • Excavate roadways • Install approx. 49000 ft of piping in branched distribution network • Backfill and repave roadways • Install four booster pumping stations • Connect residences to new supply line; install corporation stops, meters, and shutoff valves <u>Temporary Alternate Water Supply Provision</u> • Provide bulk or bottled water, or point-of-entry treatment during 1 - 2 year interim design and construction period depending on degree of risk reduction warranted	<u>Long-term System O&M</u> • Distribution line O & M would be responsibility of new water authority or of municipal water supplier <u>Alternate Water Provision</u> • Provide bottled or bulk water, or point-of-entry O&M during design and construction period <u>Institutional Controls</u> • Local health or construction ordinances to prohibit use of contaminated, untreated ground or spring water for potable use (drinking, growing vegetables, etc.) • Deed restrictions to prevent use of contaminated private wells at affected properties <u>Long-term Monitoring</u> • Semi-annual sampling of 55 groundwater locations (private residential water wells, springs, and monitoring wells) • Analyze collected samples for VOCs and metals • Compile and document results <u>Five-Year Reviews</u> • Review collected analytical results • Assess contaminant migration status • Identify whether additional residential wells are at risk • Determine whether further remedial actions are needed

FIGURE 3-6
KEY COMPONENTS OF ALTERNATIVE 5 - NEW MUNICIPAL SUPPLY WELL AND TREATMENT
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, BERKS COUNTY, PA

IMPLEMENTATION PERIOD	POST-IMPLEMENTATION PERIOD
New Well Field Acquisition • Locate new potential well field • Conduct hydrogeologic investigations to assess aquifer capacity **Treatment and Distribution System Design** • Engineering assessment of water use and demand • Design system to produce potable water • Design water storage and distribution system **Treatment Systems Installation** • Construct treatment plant • Install equalization, aeration, chemical oxidation, sedimentation, filtration, and disinfection treatment units **Distribution System Installation** • Install approx. 56000 ft of distribution piping • Install new elevated storage tank • Connect residences to new supply line **Temporary Alternate Water Supply Provision** • Provide bulk or bottled water, or point-of-entry treatment during 1 - 2 year interim design and construction period	**Long-term System O&M** • Operate and maintain treatment system and distribution mains **Institutional Controls** • Local health or construction ordinances to prohibit use of contaminated, untreated ground or spring water for potable use (drinking, growing vegetables, etc.) • Deed restrictions to prevent use of contaminated private wells at affected properties **Long-term Monitoring** • Semi-annual sampling of 55 groundwater locations (private residential water wells, springs, and monitoring wells) • Analyze collected samples for VOCs and metals • Compile and document results **Five-Year Reviews** • Review collected analytical results • Assess contaminant migration status • Identify whether additional residential wells are at risk • Determine whether further remedial actions are needed

eliminate further exposures (through drinking, inhalation or dermal contact) to VOC and metal contaminants in the groundwater. The water supply would be replenished periodically. Institutional controls such as ordinances or deed restrictions may be enacted to prohibit the use of contaminated groundwater for drinking water. Existing residential supply wells and selected monitoring wells would be incorporated into a long-term monitoring network to determine whether the water supplies of other residences may be affected and to determine the status of groundwater contamination. Groundwater would be monitored annually for VOCs and metals to assess the status of the contaminant plume and whether additional residences may be at risk from contaminated groundwater. Because contaminants remain in the aquifer and would continue to pose threats to groundwater users, 5-year reviews would be conducted to assess site conditions and whether additional response actions are necessary.

Bottled or Bulk Water Supply - For residences where the principal exposure to contaminants is through ingestion, the provision of bottled water would be adequate to protect the health of the residents. For homes where the water supply contaminant concentrations are sufficiently high to cause excess risks through all exposures (ingestion, inhalation, and dermal contact), based on the preliminary risk assessment estimates, bulk water would be provided. Under this alternative, these residences would be provided with polyethylene (PE) storage tanks (probably up to 1,000 gallons total capacity) to store the delivered bulk water. Using an estimated typical 125 gallons per day per capita water usage rate, the typical home with four residents may require up to 500 gallons per day. Therefore, the tanks would probably be replenished three times per week. Bulk water may be obtained from either private suppliers or possibly from the borough of Bally's Municipal Water Department (see Section 3.2.5 regarding Bally's water supply).

Institutional Controls - Institutional controls such as local health or building ordinances would be implemented under this alternative to prohibit the use of untreated contaminated groundwater for drinking, thereby preventing potential exposures by the residents to VOC and metal contaminants. New supply wells could be required to have effective treatment units, and groundwater from existing contaminated private or commercial wells would be required to have treatment prior to use. These requirements may be implemented as conditions attached to building permits for new constructions or modifications of existing structures and an inspection program may be instituted to verify the use of treatment systems. Deed restrictions may be imposed on the titles of properties, if the owner is willing, to restrict the use of the private wells. However, deed restrictions are anticipated to be difficult to implement and enforce.

Provision of Delivered Water - The number of residences affected by contaminated groundwater will be determined through the identification of residential wells and springs having contaminants in excess of

MCLs or risk-based action levels, as determined by a sampling and analysis program. The analytical results from the December 1995 sampling round and the cumulative results from the historical analytical data indicate that 29 water supplies exceed allowable drinking water quality criteria. For these households, either bottled water or bulk water would be provided under this alternative to prevent further exposure to site contaminants through ingestion, which is the primary exposure pathway.

If provision of bottled water is selected to prevent further ingestion of contaminated groundwater, then only quantities sufficient to address drinking water use (i.e., drinking, cooking) would be needed. Using an estimated bottled water consumption rate of approximately 5 gallons per person every 2 weeks, an average sized family of four would use about 40 to 50 gallons monthly.

As discussed, bulk water would need to be provided to residences where the contaminant concentrations are sufficiently high to cause excess risk through either the dermal or inhalation pathways. Under this scenario, it is anticipated that storage tanks would be installed at each of the affected residences and bulk water deliveries would be made periodically. As a result of initial contacts with several bottled and bulk water vendors, a number of firms were identified that could readily provide bottled water. However, only one firm and one municipal authority were identified that could provide potable water in bulk. Other vendors only provided bulk water for non-drinking water use, such as filling swimming pools. Therefore, the use of delivered bulk water may only be a limited option.

Long-term Monitoring - A long-term monitoring well network would be established under this alternative to assess whether additional residential wells would be affected by contaminants and to assess the contaminant plume migration status. Long-term monitoring would also be useful in identifying when the use of a private water supply can be resumed. Because contaminants would remain at the Crossley Farm Site (source area) and no groundwater response actions (containment or remediation) would be implemented in the short term, the contaminant plume is likely to migrate and affect other downgradient residential supply wells. Residents that use groundwater in the study area would remain at risk. It is anticipated that, annually, a total of approximately 50 residential and monitoring wells would be sampled and analyzed for VOCs and metals. The assembled sampling results would be used to determine whether additional residential wells have been contaminated and additional actions are needed.

Five-Year Reviews - Every 5 years, the groundwater data would be reviewed to assess the status and condition of the site source areas, the status of groundwater contamination, changes in potential risks, and whether imminent hazards are posed by site contaminants.

3.2.3 Alternative 3: Point-of-Entry Treatment

Alternative 3 calls for the use of point-of-entry treatment units to treat the extracted groundwater at each affected residence. Groundwater pumped from the private wells or springs would be passed through the treatment systems at the point of entry into the homes. Through the provision of these treatment systems, contaminant concentrations would be reduced to below the drinking water criteria (MCLs). Institutional controls such as ordinances or deed restrictions may be enacted to prohibit the use of contaminated groundwater for drinking water use, if treatment is not employed. Existing residential supply wells and selected monitoring wells would be incorporated into a long-term monitoring network that would be used to determine whether the water supplies of other residences may be affected and the status of groundwater contamination. Annual monitoring of groundwater for VOCs and metals would be performed to assess the contaminant plume status and to assess whether additional homes may be at risk from contaminated groundwater. Because contaminants remain in the aquifer and would continue to pose threats to groundwater users, 5-year reviews would be conducted to assess site conditions and whether additional response actions are necessary.

Carbon adsorption was chosen as the process option to be used for the point-of-entry units. Factors favoring the selection of carbon adsorption included a much greater availability and selection of manufacturers, materials, and suppliers. The carbon units fit inside the homes and can relatively easily be incorporated into the residential plumbing system. Each treatment system would be composed of a prefilter to remove suspended solids, dual in-series activated carbon units to remove VOCs, an in-line water softener unit to remove manganese and iron (if needed), activated alumina to remove lead (if needed), and an ultraviolet (UV) radiation unit to provide disinfection. The activated carbon would be replaced periodically basis or when breakthrough is identified.

Residential air stripping units are not readily available; there is not a large selection of manufacturers, materials, and suppliers. These units may be somewhat noisy, and there is some question as to how easily they may fit inside a home or be incorporated into the plumbing system. If the unit was placed inside the home, the air emissions would need to be captured by a carbon system. In addition, one vendor contacted indicated that, at the levels of contamination found near the site, the outflow water from the stripper would probably need to be polished by a carbon unit.

Water Treatment - Currently, EPA is providing point-of-entry treatment units to 15 residences in the vicinity of the Crossley Farm Site. The proposed general treatment system schematic for Alternative 3, depicted in Figure 3-2, is similar to the systems currently installed in the residences in the study area. However, it is anticipated that each affected residence's water contaminant situation would be evaluated separately to determine the specific system configuration required. For wells where the water supply pH is low (pH of less than 6.0), the treatment system would be equipped with an acid neutralizer. Some modification to each home's plumbing or piping system and to the electrical outlets and connections would be necessary. Implementation of this alternative assumes that space would be available in each residential unit for the area and volume to be occupied by the treatment system.

Acid Neutralizer - For homes with historical pH levels lower than 6.0, an acid neutralization system may be installed to raise the pH to between 6 and 8, which is the range recommended by the American Water Works Association, and to prevent excess corrosion of the treatment system. Lime would be fed by the neutralizer into the extracted groundwater to raise the pH. All residences with pH in the typical range would not require the acid neutralizer.

Pre-filter - A 5-micron filter would be the first component of the treatment system (unless there is an acid neutralization unit) to remove suspended solids and materials and to prevent fouling of the activated carbon units. Replaceable filters would be used and provided to the residents.

Activated Carbon - Based on the array of contaminants detected in groundwater, two activated carbon adsorption units (primary and secondary) would be installed in series after the pre-filter in each affected residence to remove the contaminants of concern to meet the drinking water criteria. In the event organic contaminant breakthrough occurred in the primary carbon unit, the VOCs would be captured in the secondary unit. Past sampling of pre-treatment and post-treatment water from the primary activated carbon unit indicates that all organic contaminants were below their respective detection limits; these contaminants could no longer be detected after the groundwater passed the activated carbon units. Past carbon usage information indicates that the primary carbon unit is replaced annually by the existing secondary unit and a new secondary unit is installed. For this alternative, it is anticipated that the same frequency for carbon replacement would be followed.

Lead Removal - A few residential supplies were identified as having lead concentrations at or near the federal MCL (15 µg/L) or exceeding the state MCL (5 µg/L). It is uncertain whether the lead presence can be attributed to the site or whether the lead is the result of leaching from residential plumbing and fixtures. If it is determined that the lead is attributable to the site, then affected homes would need to have a treatment system to remove or reduce the lead concentrations to below 5 µg/L. Several options are available, including reverse osmosis, activated alumina, or ion exchange units. Analytical results would be reviewed to determine the need for the lead removal.

Water Softener - Water softening to remove iron and manganese may be achieved through chemical treatment or through ion echange. High manganese levels have been identified under the preliminary risk assessment as contributing to noncarcinogenic risks. The high concentrations of iron and manganese present in some of the extracted groundwater may pose aesthetic problems such as odor and discoloration. Excessive iron and manganese presence may cause scaling on the UV lamp assembly and reduce or retard the effectiveness of the water disinfection unit. If required, a water conditioner would be incorporated into the treatment system following the activated carbon units. The iron and manganese would be removed by synthetic resins or zeolites. Currently, the water conditioner resin is replaced every 56 days. However, it isanticipated that analytical sampling results would be reviewed to corroborate whether the current frequency for resin or zeolite replacement is appropriate.

Disinfection - To ensure that the finished water does not promote the growth of microbiological organisms that may pose threats to the residents, ultraviolet irradiation of the treated water would be conducted. Water already treated by activated carbon and the resin would be passed through a final treatment unit using a UV lamp assembly to inactivate or kill pathogens. This UV treatment would be effective against bacteria and viruses. As discussed previously, the water entering the UV treatment should have relatively low levels of iron and manganese to prevent fouling of the lamps.

Institutional Controls - Institutional controls to be implemented under Alternative 3 would be the same as for Alternative 2. The use of contaminated groundwater would be prohibited under this alternative, thereby preventing potential exposures by the residents to VOC and metal contaminants. Local health or building ordinances could be enacted under this alternative to prevent the use of untreated groundwater for drinking water. New supply wells may be required to have effective treatment units, and groundwater from existing contaminated private or commercial wells would be required to have treatment prior to use. These requirements may be implemented as conditions attached to building permits for new constructions or modifications of existing structures, and an inspection program may be instituted to verify the use of treatment systems. Deed restrictions may be imposed on the titles of properties, if the owner is willing, to restrict the use of the private wells. However, deed restrictions are anticipated to be difficult to implement and enforce.

Long-term Monitoring - As in Alternative 2, a long-term monitoring well network would be established under Alternative 3 to assess whether additional residential wells would be affected by contaminants and to assess the contaminant plume migration status. Long-term monitoring would also be useful in identifying when the use of a private water supply can be resumed. Because contaminants would remain at the Crossley Farm Site (source area) and no groundwater response actions (containment or remediation) would be implemented in the short term, the contaminant plume is likely to migrate and affect other downgradient residential supply wells. Residents that use groundwater in the study area would remain at risk. It is anticipated that, annually, a total of approximately 50 residential and monitoring wells would be sampled and analyzed for VOCs and metals. The assembled sampling results would be used to determine whether additional residential wells have been contaminated and additional actions are needed.

Five-Year Reviews - Every 5 years, the groundwater and residential wells monitoring data would be reviewed to assess the status of the site source areas and their condition, status of groundwater contamination, changes in potential risks, and whether imminent hazards are posed by site contaminants.

3.2.5 Alternative 4: Water Line

Under this alternative, the distribution water main from the nearby borough of Bally would be extended throughout Hereford and Washington Townships so that service lines could be provided to all affected residences. The extension would require excavations in or along public roadways, installation of the underground piping for the distribution main, installation of service lines to the property lines of affected residences, and connection of the service lines to the plumbing system within each household. While the water line extension is being constructed, residences with contaminated groundwater in excess of drinking water criteria (MCLs) or risk-based action levels would be provided temporarily with an alternate water supply.

According to the Bally Municipal Water Department manager (Bally, 1995), the water department is currently using one of two supply wells to provide potable water to residential, commercial, and industrial customers. The water department is highly interested in expanding its service and providing potable water to other customers. Bally obtains its water supply from the bedrock aquifer underlying the borough and treats the supply prior to distribution.

Coordination among EPA, PADEP, the borough of Bally, and Hereford and Washington Townships would be required for the construction of the water line extension and connections to 29 affected residences. However, the long-term administration, management, and service of the water line and the pumping stations would probably be the responsibility of a water authority that would be jointly managed by the local governments.

The administration, management, and long-term operation and maintenance of the extraction well and treatment would remain the responsibility of the borough of Bally. Therefore, no long-term or operation and maintenance activities related to the water line would be anticipated under this alternative.

Institutional controls would be required to prevent the installation of new private wells that do not include treatment or to prevent the use of untreated groundwater from existing wells. New private residences would be given the option to either connect to the new water supply provided by Bally or be required to provide treatment of their water.

Since contaminants remain at the site and are continuing sources of VOCs to groundwater, long-term groundwater monitoring and 5-year reviews would be required.

Borough of Bally Municipal Water Supply

The borough of Bally, adjacent to Hereford Township, has a municipal water supply that currently provides water to approximately 329 residential units, 10 commercial operations, and six industrial operations. The Bally Municipal Water Department currently uses one supply well to extract approximately 300,000 gallons per day (gpd) year round from the underlying aquifer.

As the result of past operating and disposal activities by a local manufacturing facility, groundwater in the aquifer underlying the borough of Bally has been contaminated by various VOC solvents. The municipal well prevents further contaminant migration by extracting contaminated groundwater from the underlying aquifer. This municipal supply/extraction well is located in the borough of Bally. The extracted groundwater is then treated using two air strippers (linked in series) to remove the VOCs, disinfected with chlorine gas, and pumped into a 275,000-gallon covered concrete storage tank prior to distribution. The treated water meets all drinking water criteria and is suitable for potable use.

Bally Municipal Water Department estimates that between 100,000 to 110,000 gallons of treated water are used per day, and the remaining 200,000 gallons are discharged (wasted) to a nearby stream. Because of the excess quantities of finished water produced per day, the water department is highly interested in expanding its service and using the surplus.

A second municipal supply well is located on the other side of town from the first well and can also produce up to 300,000 gpd. This second well is currently unused because of the concern that pumping this well may cause the contaminated groundwater to migrate in a different direction. However, there are plans to use the second well in a reserve capacity if additional water is required. Currently, the water department does not have a supplemental source of water."

The water department analyzes the finished water supply on a weekly basis for the contaminants known to be associated with past disposal activities. To date, these contaminants have not been detected in the treated water. The full suite of chemical analyses is performed every quarter.

The water department typically brings a service line from the distribution main to the edge of a private property. The property owner is then responsible for connecting his residential piping system with the service line. The water department currently charges $2.25 per 1,000 gallons. There is a minimum charge of $22.50 per month. For a family of four using 125 gallons of water per person per day (a total of 500 gallons per day, or 15,000 gallons per month), the monthly charge would be $33.75.

Water Line Extension and Installation

To extend the distribution main from Bally Borough into Hereford and Washington Townships, 8-inch-diameter piping would be required. For the FFS, both branched and looped (grid) distribution networks were considered. A looped distribution network is more expensive but is generally preferable to a branched network because of its greater reliability. Water could be provided to each residence from two pathways with the grid system. Figure 3-7 depicts the distribution line extensions from Bally.

For the branched distribution system, the water line would extend along Old Route 100 and turn north onto Forgedale Road. The water line would then extend along Forgedale Road and branch at Dale Road. The water line would extend along Dale Road and branch onto Dairy Lane, Airport Road, and Mensch Mill Road. Finally, the water line would intersect Huffs Church Road and extend eastward. Installation of the distribution lines would require excavation along the centers of roadways since almost all roads in the study area do not have any shoulders or adequate right-of-ways. It is anticipated that the distribution lines would be installed at least 36 inches below ground surface to prevent freezing.

Approximately 49,000 linear feet of ductile iron lined with cement pipes would need to be installed to serve as the distribution main. Based on the need to provide service lines to 29 affected water supplies, an additional 2,900 feet of pipes (100 feet per lateral connection) would be required. Ductile iron with a cement liner was selected for the FFS because of the inherent strength of the material and because the cement liner reduces the corrosion of the iron and formation of tubercles by iron bacteria, which could cause problems with the water quality.

The looped or gridded distribution network is generally similar to the branched network except that the "dead ends" in the distribution line are eliminated through the extension of the branched lines back into the

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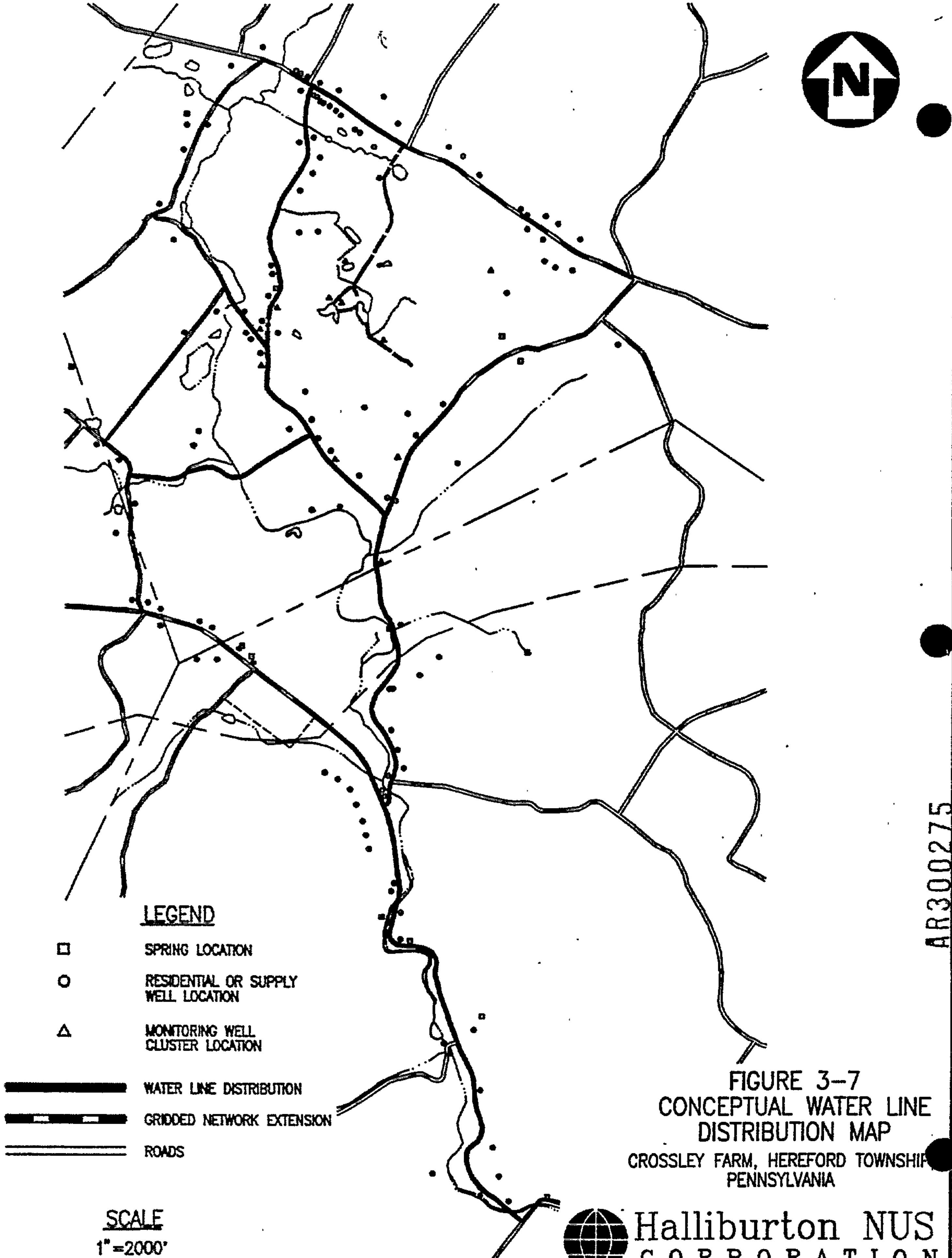

FIGURE 3-7
CONCEPTUAL WATER LINE DISTRIBUTION MAP
CROSSLEY FARM, HEREFORD TOWNSHIP, PENNSYLVANIA

Halliburton NUS CORPORATION

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regional distribution network (Figure 3-7). For the looped distribution network, approximately 80,000 linear feet of ductile iron lined with cement pipes would need to be installed to serve as the distribution main and to make the lateral connections.

Due to the distance that the Bally-derived water must travel to reach the study area and the corresponding length of time that the water will be in contact with the pipes, the degradation of water quality aesthetics (such as color, odor, and taste) would be of concern. Therefore, the following additional measures could be taken to protect the aesthetic quality of the water. The water would be properly chlorinated and contain sufficient chlorine residuals to inhibit bacterial growth, which, uninhibited, could cause taste and odor problems. The proper periodic maintenance of the system would be performed, including a periodic flushing of the lines to remove any stagnant water. The pH of the finished water would be monitored to ensure that it is not corrosive, which unchecked could result in an attack of the pipe materials. Backflow preventers (or other measures such as privately owned supply tanks) could be installed to prevent accidental cross-contamination by industrial or commercial users (if any), which could accidentally pump process water into the water lines.

The actual design of the water distribution system would require a careful engineering evaluation to determine actual water usage, the actual topographic changes, friction losses, fire protection needs, and the future growth of the service area.

Pumping

Because of the extensive distances and substantial changes in elevation between Bally and the residences in Hereford and Washington Townships, the existing system pressure is unlikely to be sufficient. Therefore, additional pumping will be required to increase the hydraulic head in the service lines. An estimated four lift stations would be required to provide adequate system pressure to the residences located along Huffs Church Road, which is the highest elevation in the area to be provided with a water line. Four centrifugal pumps would be used to develop the necessary hydraulic head for the piped water. In addition, four other pumps would be available for stand-by operations.

An elevated storage tank could be erected and used to store and distribute the potable water if a suitable location is identified. Elevated storage would be desirable since system pressure can be better regulated and pumping can be done at night when utility rates are cheaper. However, the availability of land to situate a water tank is unknown. For the FFS, it is assumed that no storage of water for the water supply is available.

Interim Water Supplies

While the design and construction of the water line are proceeding, interim water supplies would be required for the 29 affected residences. It is anticipated that point-of-entry systems would be provided for all residences. A description of the point-of-entry system is presented in Section 3.2.3. For this FFS, it is estimated that the remedial action would require between 3 and 4 years to complete.

Institutional Controls - Institutional controls to be implemented under Alternative 4 would be the same as those proposed for Alternative 2. The use of contaminated groundwater would be prohibited, thereby preventing potential exposures by the residents to VOC and metal contaminants. Local health or building ordinances could be enacted under this alternative to prevent the use of untreated groundwater. New supply wells would be required to have effective treatment units, and groundwater from existing contaminated private or commercial wells would be required to have treatment prior to use. These requirements may be implemented as conditions attached to building permits for new constructions or modifications of existing structures, and an inspection program may be instituted to verify the use of treatment systems. Deed restrictions may be imposed on the titles of properties, if the owner is willing, to restrict the use of the private wells. However, deed restrictions are anticipated to be difficult to implement and enforce.

Long-term Monitoring - As in Alternative 2, a long-term monitoring well network would be established under Alternative 4 to assess whether additional residential wells would be affected by site-related groundwater contaminants and to assess the migration status of the contaminant plume. Because contaminants would remain at the Crossley Farm Site (source area) and no groundwater response actions (containment or remediation) would be implemented in the short term, the contaminant plume has the potential to migrate and affect other downgradient residential supply wells. Residents that use groundwater in the study area would remain at risk. It is anticipated that a total of approximately 50 residential and monitoring wells would be sampled and analyzed annually for VOCs and metals. The analytical data would be used to determine whether additional residential wells have been contaminated and additional actions are needed.

Five-Year Reviews - Every 5 years, the groundwater data would be reviewed to assess the status and condition of the site source areas, the status of groundwater contamination, changes in potential risks, and whether imminent hazards are posed by site contaminants.

3.2.4 Alternative 5: New Municipal Water Supply Well with Treatment

Under Alternative 5, a new community well field would be established in Hereford or Washington Township (or in their vicinity), a water supply well would be installed, a water treatment plant would be constructed, distribution mains would be installed throughout Hereford and Washington Townships, and private residences with contaminated drinking water supplies would be connected to the municipal water system. Through the provision of a new municipal water supply, residents in the study area would not be at risk from ingestion, inhalation, or dermal exposures to contaminants currently present in the groundwater. The treated groundwater would meet federal and state drinking water criteria. The supply well and treatment system could be designed to accommodate additional residences if it is determined that other private water supplies would also become affected. A hydrogeologic investigation would be required to determine the suitability of the selected well field and assess the aquifer capacity, and a detailed engineering evaluation would be required to design the treatment system and water supply distribution system.

Once a remedial action is selected for the affected residences water supply, it is estimated that the identification of a suitable piece of property for a well field, the hydrologic investigations, and the engineering design and construction of the supply well and treatment system would require about 2 to 4 years to complete. In the interim, residences with contaminated water supplies would be provided with a safe alternative water source such as bottled or bulk delivered water (described in Alternative 2) or point-of-entry treatment systems (described in Alternative 3).

Institutional controls such as ordinances or deed restrictions may be employed to prohibit the use of contaminated groundwater for drinking water, if treatment is not employed. Existing residential supply wells and selected monitoring wells would be incorporated into a long-term monitoring network that would be used to determine whether the water supplies of other residences may be affected and the status of groundwater contamination. Annual monitoring of groundwater for VOCs and metals would be performed to assess the contaminant plume status and to assess whether additional homes may be at risk from contaminated groundwater. Because contaminants remain in the aquifer and would continue to pose threats to groundwater users, 5-year reviews would be conducted to assess site conditions and whether additional response actions are necessary.

Long-term operation and maintenance of the municipal well field and the treatment system and administration and management of the water supply would be required.

New Municipal Well Field and Well - A new public well field would be established under this alternative. However, a review of the existing township property maps indicates there may not be publicly owned properties available for the location of a public water supply well field and a water treatment facility. It is possible that privately owned land would need to be acquired for use as a well field within or outside Hereford and Washington Townships. The property would need to be sufficiently large to establish a well field, be undeveloped, have a protected water shed, and be uncontaminated. The groundwater underlying the land should be free of contamination. Any activities that may impair the groundwater quality could be prohibited through local ordinances to preserve the quality of the water supply. The proposed new water treatment facility may be located at the same property as the well field, if there is sufficient space, or could be located elsewhere.

Ideally, the supply wells and the treatment plant would be located at a higher topographic location than the residences and private properties. In this way, treated groundwater could be sent to pumped storage or distributed to the residences using gravity rather than by pumped flow. However, such a location within Hereford Township would place the well field very close to the Crossley Farm Site, where numerous contaminants remain.

Once a suitable piece of property has been located, aquifer tests would need to be conducted to assure that the water-bearing formation has the capacity to accommodate the water supply demand of the community. Groundwater samples would be obtained to assess the quality of raw water; this information would be used to design the treatment system. One major uncertainty is the current extent of the contaminated groundwater plume associated with the Crossley Farm Site. As part of the aquifer test, it would be necessary to ascertain whether the contaminant plume may be induced to flow toward or into the supply well location. If the aquifer test indicates that the contaminant plume is being affected by pumping, then a new well depth or new location would need to be selected.

Treatment

For this FFS, the goal of treatment is to produce a finished water that meets federal and state drinking water criteria that include the Safe Drinking Water Act MCLs, the state MCLs, and, as appropriate, the secondary MCLs for aesthetic purposes. A typical average water consumption rate is estimated to be 125 gallons per person per day. For the 29 affected households identified to date, at an average of four persons per household, a total of 116 residents would need to be provided with treated groundwater from the new system. Therefore, an estimated daily average of 14,500 gallons of treated water would be required. Under peak usage conditions, the water consumption rate is anticipated to be higher. As part of the engineering evaluation, the average and peak potable water consumption rates for the Hereford and Washington Township communities would need to be assessed so the treatment system can be properly sized and designed. Because of the small number of residences to be serviced, either an engineered treatment system or a package treatment system could be used.

The quality of the raw water from the supply well should be properly characterized so that an effective and efficient water treatment system can be designed and constructed. A set of possible treatment processes is presented in the following narratives; however, the design should be based on the actual results of field and laboratory studies:

Equalization - Water extracted from the supply well would be mixed in a tank so the temperature, pH, metals (iron, manganese), and alkalinity can be equilibrated to provide a more uniform raw water mixture for subsequent treatment.

Aeration - The raw water would be aerated to increase the dissolved oxygen content so that taste- and odor-producing compounds (e.g., hydrogen sulfide, carbon dioxide, nitrogen, and methane) may be removed through intimate contact with ambient air. Aeration also contributes to the oxidation of iron, manganese, hydrogen sulfide, and naturally occurring organic materials. Oxidation of the soluble iron and manganese results in insoluble precipitates that can be removed through subsequent treatment. Aeration may be accomplished using multiple tray assemblies, sprays, cascades, diffusers, or bubblers.

Chemical Oxidation - Should aeration prove insufficient for the removal of iron or manganese, chemicals such as chlorine or potassium permanganate may be added to further oxidize these metal ions into an insoluble form that can be removed through subsequent filtration. The ideal goal of treatment is to have a finished water with 0.05 to 0.3 mg/L of iron and 0.01 to 0.05 mg/L of manganese. If chlorine were used, a residual concentration would be maintained throughout the treatment process to provide disinfection.

Softening - If the water from the supply well is determined to have excessively high alkalinity (calcium and magnesium), the water may be treated with lime and soda ash, causing the formation of calcium and magnesium precipitates that can be removed through subsequent filtration. Several references suggest an alkalinity of between 60 and 120 mg/L as calcium carbonate. Softening may be used also for iron and manganese removal. Depending on the quality of water obtained from the supply well, softening can be used to remove most of the metals that affect water quality.

Sedimentation - After the precipitation of the iron, manganese, calcium, and magnesium, the treated water would be discharged to a sedimentation basin where the precipitated sludge may be removed through gravity.

Filtration - This step would be used to remove precipitates of iron and manganese, calcium, and magnesium. A sand filter that can be backwashed periodically to maintain its removal efficiency of suspended particles could be used as part of this treatment train.

Disinfection - The final treatment step consists of chlorinating the filtered water to provide disinfection of pathogens. Gaseous or liquid chlorine would be used as the disinfecting agent. A chlorine residual would be maintained to ensure that the finished water has been properly disinfected.

Pumped Storage - The finished water can be stored in an above-ground or elevated storage tank to meet the demand for a 24-hour cycle. Ideally, the storage tank would be located at or near the center of use and would be situated at an elevation sufficiently high to provide adequate service water pressure to the residences.

As discussed, the wells would draw from the bedrock aquifer. Data collected to date indicate that neither high turbidity nor highly elevated metals content are water quality problems with the groundwater drawn from this aquifer. Therefore, it is not anticipated that precipitation or coagulation/flocculation would be required.

Distribution and Connection - To provide the finished water to the affected residences under Alternative 5, distribution mains would need to be installed along Forgedale Road, Kemp Road, Long Lane Road, Mensch Mill Road, Conrad Road, Huffs Church Road, Dale Road, and Dairy Lane. Installation of the distribution lines would require excavation along the centers of roadways since almost all roads in the study area do not have any shoulders or adequate right-of-ways. It is anticipated that the distribution lines would be installed at least 36 inches below ground surface to prevent freezing. Approximately 55,700 linear feet of pipes would need to be installed to serve as the distribution main. Based on the need to provide service lines to 29 affected private water supplies, an additional 2,900 feet of pipe (100 feet per lateral connection) would be required. Service lines would be extended from the distribution mains to each residence and connected to water meters, pressure regulators, and finally to the plumbing systems.

Interim Water Supplies

While the design and construction of the water line are proceeding, interim water supplies would be required for the 29 affected residences. It is anticipated that point-of-entry systems would be provided for all. A descriptions of the point-of-entry system is presented in Section 3.2.3.

Institutional Controls - Institutional controls to be implemented under Alternative 5 would be the same as those proposed for Alternative 2. The use of contaminated groundwater for drinking without treatment would be prohibited under this alternative, preventing potential exposures by the residents to VOC and metal contaminants. Local health or building ordinances may be enacted under this alternative to prevent the use of untreated groundwater. New supply wells may be required to have effective treatment units, and groundwater from existing contaminated private or commercial wells would be required to have treatment prior to use. These requirements may be implemented as conditions attached to building permits for new constructions or modifications of existing structures, and an inspection program may be instituted to verify the use of treatment systems. Deed restrictions may be imposed on the titles of properties, if the owner is willing, to restrict the use of the private wells. However, deed restrictions are anticipated to be difficult to implement and enforce.

Long-Term Monitoring - As in Alternative 2, a long-term monitoring well network would be established under Alternative 5 to assess whether additional residential wells would be affected by site-related groundwater contaminants and to assess the contaminant plume migration status. Because contaminants would remain at the Crossley Farm Site (source area) and no groundwater response actions (containment or remediation) would be implemented in the short term, the contaminant plume is likely to migrate and affect other downgradient residential supply wells. Residents that use groundwater in the study area would remain at risk. It is anticipated that, annually, a total of approximately 50 residential and monitoring wells would be sampled and analyzed for VOCs and metals. The assembled sampling results would be used to determine whether additional residential wells have been contaminated and additional actions are needed.

Five-Year Reviews - Every 5 years, the groundwater data would be reviewed to assess the status of the site source areas and their condition, status of groundwater contamination, changes in potential risks, and whether imminent hazards are posed by site contaminants.

3.3 ALTERNATIVES SCREENING

The NCP states that remedial alternatives can be screened, if necessary. The purpose of the screening is to reduce the number of alternatives that will undergo a more thorough and extensive analysis. Each alternative is screened against the three broad screening criteria of effectiveness, implementability, and cost. The alternatives were not evaluated against each well exhibiting a risk. Rather, each alternative was evaluated versus its effectiveness at meeting the remedial action objective and in reducing risks posed to residents using contaminated groundwater and its implementability.

Because of the uncertainties associated with the current status of the contaminated groundwater plume, Alternative 5 (new supply well with treatment) was eliminated from further consideration. The nature and extent of the groundwater contaminant plume, how contaminants are migrating, and the pathways of contaminant migration are being addressed by the ongoing remedial investigation. It is possible that the installation of a high-capacity supply well under Alternative 5 could result in inadvertent changes to contaminant flow patterns and the capture of contaminants by the supply well. The well installation could also exacerbate the existing groundwater problem before a remedy can be implemented. If contaminated groundwater of unknown concentrations and distribution is used for a water supply, the design of the treatment system will need to accommodate a variety of operating conditions. Given all these uncertainties, it is impractical to design an effective water treatment system without much more information. Therefore, Alternative 5 is not considered to be technically implementable.

Each of the remaining four alternatives passed the screening process and will be evaluated in detail in this FFS. The screening summary is presented in Table 3-1.

TABLE 3-1
ALTERNATIVES SCREENING
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

ALTERNATIVE	EFFECTIVENESS	IMPLEMENTABILITY	COST	STATUS
1. No Action	- Would <u>not</u> meet the PRG because it would <u>not</u> prevent use and ingestion of contaminated groundwater. - Would <u>not</u> reduce the toxicity, mobility, or volume of contaminated groundwater. - Would <u>not</u> provide protection of nearby residents in the short and long term.	- Since there are no response actions, this alternative is readily implemented. - Long-term monitoring can be readily implemented.	Capital: None O & M: Low	Retained, as required by the NCP.
2. Delivered Water	- Would meet the PRG by preventing the use and ingestion of contaminated groundwater. - Would <u>not</u> reduce the toxicity, mobility, or volume of contaminated groundwater. - Would provide protection of nearby residents in the short and long term. - Should additional wells become contaminated, those residences can readily be provided with delivered water.	- Readily implemented since a number of bottled water providers are available. Bulk water not as readily available. Supplied water would meet MCLs. - Replenishment of supplied water is readily accommodated. - Long-term monitoring would be readily implemented. - Administratively implementable because only one agency is required to manage provision of supplied water. - No treatment, storage, or disposal (TSD) facilities required.	Capital: Low O & M: Low	Retained

TABLE 3-1
ALTERNATIVES SCREENING
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

ALTERNATIVE	EFFECTIVENESS	IMPLEMENTABILITY	COST	STATUS
3. Point-of-Entry Treatment	- Would meet the PRG by preventing the use and ingestion of contaminated groundwater. - Would reduce the toxicity, mobility, or volume of contaminated ground water. - Would provide protection of nearby residents in the short or long term. - Should additional wells become contaminated, those residences can readily be provided with point-of-use systems.	- Readily implementable because vendors are available in eastern Pennsylvania to provide residential water treatment units. Treated water would meet MCLs. - Vendors are also available to maintain systems, perform sampling, and replace used treatment system components. - Long-term monitoring would be readily implemented. - Administratively implementable because only one agency is required to manage provision of supplied water. - No treatment, storage, or disposal (TSD) facilities required directly for point-of-use systems.	Capital: Moderate O & M: Moderate	Retained

TABLE 3-1
ALTERNATIVES SCREENING
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA
PAGE 3 OF 4

ALTERNATIVE	EFFECTIVENESS	IMPLEMENTABILITY	COST	STATUS
4. Water Line	- Would meet the PRG by preventing the use and ingestion of contaminated groundwater. - Would <u>not</u> reduce the toxicity, mobility, or volume of contaminated groundwater. - Would provide protection of nearby residents in the short or long term. - Should additional wells become contaminated, those residences can be connected to the new water line.	- Can be implemented since nearby borough of Bally has ample municipal water supply. Supplied water would meet MCLs. - Installation of water lines feasible only because standard construction equipment, materials, and personnel are required. - Long-term monitoring would be readily implemented. - Administratively implementable but may be moderately difficult because coordination among federal and state agencies, Hereford Township, and Bally Borough would be required to manage water supply distribution and collection of water usage fees. - No treatment, storage, or disposal (TSD) facilities required directly from water line installation. Bally's municipal water department may require TSD facilities to dispose of spent treatment supplies.	Capital: High O & M: Low	Retained

TABLE 3-1
ALTERNATIVES SCREENING
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PENNSYLVANIA
PAGE 4 OF 4

ALTERNATIVE	EFFECTIVENESS	IMPLEMENTABILITY	COST	STATUS
5. New Supply Well(s) with Treatment	- Would meet the PRG by preventing the use and ingestion of contaminated groundwater. - Would reduce the toxicity, mobility, or volume of contaminated groundwater. - Would provide protection of nearby residents in the short or long term. - Should additional wells become contaminated, those residences can be connected to the new public water supply.	- Too many unknowns associated with installing a large-capacity water well in a contaminated aquifer. Contaminant distribution and migration are as yet undefined. New supply well may draw large quantities of contaminants into it. - Technically implementable since contractors are available to install water wells and design and install municipal water treatment systems. Standard construction equipment, materials, and personnel available to install water main and distribution lines. However, unknown contaminant concentrations and distribution may pose difficulties for the design and during plant operations. Treated water would likely meet MCLs. - Personnel are available to operate and maintain the treatment system and perform long-term monitoring. - Administratively implementable but may be extremely difficult because coordination among federal and state agencies and the municipality would be required to manage water supply distribution. - Since public lands are not available in Hereford Township for a new well field, land acquisitions and takings would be required and may be administratively difficult to implement. - Treatment, storage, or disposal (TSD) facilities may be required if treatment residuals are generated that require disposal.	Capital: High O & M: High	Eliminated, because of uncertainty associated with status of groundwater plume.

4

4.0 DETAILED ANALYSIS OF ALTERNATIVES

The remedial alternatives developed in Section 3.0 are described and analyzed in detail in this section. The detailed analysis of the alternatives provides information to facilitate selection of a specific remedy or combination of remedies. The detailed analysis of alternatives was developed in accordance with the NCP [40 CFR 200.430(e)] and the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA Interim Final, October 1988).

In conformance with the NCP, seven of the following nine criteria were used to evaluate each of the retained alternatives during the detailed analysis. The last two criteria, state and community acceptance, will be addressed following the receipt of state and public comments on the Proposed Plan.

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

Under the NCP, the selection of the remedy is based on the nine evaluation criteria, which are categorized into three groups:

- Threshold Criteria - The overall protection of human health and the environment and compliance with ARARs are threshold criteria that each alternative must meet in order to be eligible for selection.
- Primary Balancing Criteria - The five primary balancing criteria represent the primary criteria upon which the analysis is based and include the long-term effectiveness and

permanence, the reduction of toxicity, mobility, or volume through treatment, the short-term effectiveness, implementability, and cost.

- Modifying Criteria - The state acceptance and community acceptance are the modifying criteria that will be considered in remedy selection.

Brief, general discussions of these evaluation criteria are presented in the following text. Detailed analyses of the remedial alternatives using the evaluation criteria are presented in Sections 4.1 and 4.3. Comparative analyses of the remedial alternatives are presented in Sections 4.2 and 4.4.

Overall Protection of Human Health and the Environment

This evaluation criterion provides a final check to assess whether each alternative provides adequate protection of human health and the environment. The overall assessment of protection draws on the assessments conducted under other evaluation criteria including long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. The evaluation focuses on whether a specific alternative achieves adequate protection, how risks are eliminated, reduced, or controlled, and whether Remedial Action Objectives (RAOs) would be achieved.

Compliance with ARARs

Applicable or relevant and appropriate requirements (ARARs) are considered during the detailed evaluation of alternatives. When an ARAR cannot be met, the basis for justification of a waiver under CERCLA, or within the specific requirement, is presented.

The actual determination of which ARARs are requirements is made by EPA in consultation with PADEP.

Long-Term Effectiveness and Permanence

Under this criterion, the alternatives are evaluated for long-term effectiveness, permanence, and the degree of risk remaining after the RAOs have been met. The following components are evaluated:

- Magnitude of residual risks - assesses the residual risk remaining from untreated wastes or treatment residuals at the conclusion of remedial actions, the remaining sources of risk, and the need for 5-year reviews.

- Adequacy and reliability of controls - assesses controls that are used to manage treatment residuals or remaining untreated wastes. This assessment includes addressing the likelihood of technologies to meet required efficiencies or specifications, type and degree of long-term management, long-term monitoring requirements, operation and maintenance (O&M) functions to be performed, uncertainties associated with long-term O&M, potential need for replacement of technical components and associated magnitude of risks or threats, degree of confidence in controls to handle potential problems, and uncertainties associated with land disposal of untreated wastes and residuals.

Reduction of Toxicity, Mobility, or Volume through Treatment

This criterion addresses the statutory preference for remedies that employ treatment as a principal element by assessing the relative performance of different treatment technologies for reducing the toxicity, mobility, or volume of the contaminated media. Specifically, the analysis should examine the magnitude, significance, and irreversibility of the estimated reductions.

The degree to which remedial alternatives employ treatment that reduces toxicity, mobility, or volume is assessed by considering the following factors:

- The treatment processes that the remedies employ, the media they would treat, and threats addressed.
- The approximate amount of hazardous materials that would be destroyed or treated.
- The degree of expected reduction in toxicity, mobility, or volume as a result of treatment.
- The degree to which the treatment is irreversible.
- The type and quantity of residuals that would remain following treatment, considering the persistence, toxicity, mobility, and bioaccumulation capacity of the contaminants of concern and impacted media.
- The ability of alternatives to satisfy the statutory preference for treatment as a principal element.

Short-Term Effectiveness

The assessment of short-term effectiveness during construction or implementation until the RAOs are met includes consideration of the following factors:

- Potential short-term impacts to the community during remedial actions and whether risks may be addressed or mitigated.

- Potential impacts to, and protection of, the workers during remedial actions.

- Potential adverse environmental impacts that result from construction and implementation of the alternative and the reliability of mitigation measures.

- Time until RAOs are achieved.

Implementability

The ease or difficulty of implementing a remedial alternative is assessed by considering the following factors during the detailed analysis:

- Technical Feasibility

  - Degree of difficulty or uncertainties associated with constructing and operating the alternative.

  - Technical difficulties associated with the technologies' reliability that could result in schedule delays.

  - Likelihood of additional remedial actions and anticipated ease or difficulty in implementation.

  - Ability to monitor the effectiveness of the remedy and risks of exposure if monitoring is insufficient to detect remedy failure.

- Administrative Feasibility

  - The need to coordinate with other offices and agencies and obtain necessary approvals and permits.

- Availability of Services and Materials

  - Availability of adequate capacity and location of treatment, storage, and disposal services, if required.

  - Availability of necessary equipment and specialists.

  - Availability of treatment technologies comprising the alternative, sufficient demonstration of the technologies, and availability of vendors.

- Availability of services and materials and the potential for obtaining competitive bids.

Cost

A detailed cost analysis is performed for each alternative to assess the net present-worth cost to implement the remedial actions. The cost analysis consists of the following:

- Estimation of capital (direct and indirect) and annual O&M costs.
- Development of costs with an accuracy in the range of +50 percent to -30 percent.
- Calculation of the present worth (capital and O&M costs) of the alternative by discounting to a base year or current year using a discount rate of seven percent.

State Acceptance

PADEP is providing input to the feasibility study process on an ongoing basis and will continue to do so throughout the public comment period. Assessment of the state concerns may not be completed until comments on the RI/FS are received. As a result, this FS does not include any additional discussion about this criterion for any of the alternatives analyzed. State concerns may be discussed, to the extent possible, in the Proposed Plan to be issued for public comment. The state concerns that will be assessed include the following:

- The state's position and key concerns related to the preferred alternative and other alternatives.
- State comments on ARARs or the proposed use of waivers.

Community Acceptance

This criterion refers to the community's comments on the remedial alternatives under consideration. The community is broadly defined to include all interested parties. Community concerns would be addressed after the public comment period, which follows the release of the RI/FS report. As a result, this FS does not include any additional discussion about this criterion for any of the alternatives analyzed.

4.1 INDIVIDUAL ANALYSIS OF ALTERNATE WATER SUPPLIES REMEDIAL ALTERNATIVES

Four alternate water supplies remedial alternatives, including the no-action alternative, were developed to address the contaminated private water supplies present in the vicinity of the Crossley Farm Site.

Detailed evaluations of each alternative are presented below. Detailed cost estimates, capital (both direct and indirect) and annual O&M, and assumptions for each alternative are presented in Appendix B.

4.1.1 Alternative 1 - No Action

The no-action alternative was developed as a baseline to which other alternatives may be compared, as required by the NCP. The only activities to be conducted under Alternative 1 would be institutional controls, long-term groundwater monitoring, and review of site conditions and risks every 5 years.

Overall Protection of Human Health and the Environment

The no-action alternative would not be protective of human health since no actions would be implemented to prevent the use of drinking water supplies contaminated by VOCs and metals. Carcinogenic and non-carcinogenic risks exceeding 1E-4 and a Hazard Index of 1.0, respectively, would remain as the result of continued use of contaminated groundwater. Groundwater contaminants would remain in excess of MCLs, thereby posing continued risks to human health through ingestion, inhalation, or dermal contact.

Long-term monitoring results could be used to assess changes in groundwater contaminant concentrations, the magnitude of off-site migration, and potential increases in risk but would not reduce overall threats or risks to affected residences. A total of 30 residential wells and springs and 25 monitoring wells would be sampled annually for VOCs and inorganic compounds.

Compliance with ARARs

There are no ARARs pertinent to the no-action alternative.

Long-Term Effectiveness and Permanence

Since no remedial actions would occur under Alternative 1, the current threats to human health through the use of contaminated groundwaters remain. Estimated carcinogenic health risks for affected residences remain in excess of 1E-4 for 11 residences, and excess noncarcinogenic risks would be reflected by a Hazard Index of greater than 1.0 for those plus an additional seven residences, for a total of 18 residences. Contaminant levels exceeding drinking water criteria (MCLs) would remain for 29 affected private water supplies.

Under the no-action alternative, no additional controls would be used to manage the groundwater contaminants in the vicinity of the site. Therefore, the evaluation of the adequacy and reliability of new controls is not possible.

Five-year reviews would be required to assess whether threats or risks are increasing or abating with time in light of future land use or changes in site conditions.

Reduction of Toxicity, Mobility, or Volume through Treatment

The no-action alternative would not reduce the toxicity, mobility, or volume of contamination through treatment, since no treatment is used to address the contaminated groundwaters. As a result, no hazardous substances would be treated or destroyed and contaminated groundwater would remain in place.

Alternative 1 would not satisfy the statutory preference for treatment to reduce risks posed by contaminated water supplies.

Short-Term Effectiveness

Since no response actions would occur, implementation of the no-action alternative would not pose additional short-term risks to the local community or to future on-site workers. For long-term monitoring, no risk to workers is anticipated if proper health and safety procedures are implemented and appropriate personal protective equipment (PPE) is used. There would be no impacts to the environment through the implementation of Alternative 1. The remedial action objective would not be achieved and the current potential health risks would remain unabated. The no-action alternative can be implemented immediately.

Implementability

Since no active remediation or response activities would occur, the no-action alternative is readily implementable. The technical feasibility criteria, including constructability, operability, and reliability, are not relevant to this alternative. Additional actions can be implemented in the future, if warranted. Since monitoring is implemented under Alternative 1, the status of contaminant presence or impacts to additional residential water supplies could be assessed.

Permits would not be required under Alternative 1. Coordination with other agencies may be required as part of the 5-year review process.

The criterion of availability of equipment and resources, treatment technologies, and TSD facilities is also not applicable to this alternative. Regulatory and technical personnel are available to perform the 5-year reviews effectively. Typical sampling equipment, laboratory analyses, and technical specialists are readily available to perform long-term monitoring.

Cost

No capital costs are associated with the no-action alternative. The average annual O&M cost for long-term monitoring is $44,120 and 5-year reviews are $23,000 per event. Over a 30-year period, the net present-worth cost is $597,117 (at a seven percent discount rate).

4.1.2 Alternative 2 - Delivered Water

Under Alternative 2, bottled or bulk water would be provided to each residence that has a water supply contaminated in excess of MCLs or risk-based action levels. Provision of delivered water would reduce or eliminate further exposures (through drinking, inhalation or dermal contact) to VOC and metal contaminants in the groundwater. Institutional controls such as ordinances or deed restrictions may be enacted to prohibit the use of contaminated water for drinking without treatment. Annual monitoring of groundwater for VOCs and metals would be performed at 30 residential wells and springs and 25 monitoring wells to assess the contaminant plume status and to assess whether additional homes may be at risk from contaminated groundwater. Because contaminants remain in the aquifer and would continue to pose threats to groundwater users, 5-year reviews would be conducted to assess site conditions and to determine whether additional response actions are necessary. The key features of Alternative 2 are identified on Figure 3-2.

Two scenarios are feasible under Alternative 2:

- Alternative 2A - All 29 currently affected residents with water in excess of MCLs would be provided with new storage tanks and delivered bulk water.
- Alternative 2B - The five homes with either an individual or cumulative risk for dermal contact and inhalation of greater than 1E-4 or an individual or cumulative Hazard Quotient greater than 1.0 for dermal contact and inhalation would be provided with bulk water to prevent contact with contaminants through these pathways, and the remaining 24 affected homes would be provided with bottled water to prevent ingestion of water in excess of MCLs.

The detailed analysis provided below is applicable to both Alternative 2 scenarios; differences are noted.

Overall Protection of Human Health and the Environment

Under Alternative 2, all residents who are currently exposed to contaminated groundwater in excess of MCLs (for drinking) or whose use of their private water supply would result in carcinogenic risk greater than 1E-4 would be protected through the provision of delivered water. Under this alternative, bottled water would eliminate ingestion (drinking) exposures for affected residents. For residences where inhalation and dermal contact result in unacceptable risks, as estimated by the preliminary risk assessment, bulk water would eliminate those exposure pathways.

Alternative 2 could provide short-term and long-term protection for residents whose water supplies have been contaminated but does not constitute a permanent solution for the contaminated water supplies. Alternative 2 is expected to comply with ARARs.

Deed restrictions and local ordinances could be used to prohibit untreated contaminated water use for drinking, thereby protecting private residences who intend to use the groundwater supplies. The long-term groundwater monitoring program would alert the responsible agency of changes in groundwater contamination or whether additional residential wells are affected by groundwater contamination.

Compliance with ARARs

Alternative 2 would be consistent with the federal and state chemical-specific ARARs for drinking water criteria since bottled or bulk water that complies with MCLs would be provided to residences.

There are no location-specific ARARs pertinent to the implementation of Alternative 2.

Alternative 2 would comply with the action-specific requirements under Title 29 of the Code of Federal Regulations for occupational safety and health since workers who perform the long-term monitoring wells or deliver bottled or bulk water would conform with these requirements

Long-Term Effectiveness and Permanence

With the implementation of Alternative 2, overall carcinogenic and noncarcinogenic risks through exposures to contaminated groundwater can be expected to be reduced to within or below EPA's acceptable risk range (1E-4 to 1E-6, and Hazard Quotient of 1.0, respectively). The provision of bottled or bulk water eliminates ingestion exposures to contaminants that result in greatest risks; provision of bulk water has the added benefit of eliminating the inhalation and dermal contact risks resulting from contaminated water supplies. However, if contaminant levels should rise in the residential supply wells of homes that are provided with bottled water, potential inhalation and dermal contact risks may be incurred.

Contaminants that are currently present in the bedrock aquifer would have the potential to migrate downgradient and may contaminate other residential wells or springs. Additional residents could be exposed to chemicals and metals that would result in unacceptable risks or the use of water supplies that do not meet drinking water criteria. Therefore, long-term monitoring and the 5-year reviews would be required to assess whether additional residential wells are contaminated and whether additional response actions are needed to mitigate health risks.

Alternative 2 would be effective in the long term but would not be permanent. Delivered water would need to be provided indefinitely until the contaminant source controls and remedial actions have been implemented so that the groundwater quality is suitable for potable use.

Long-term management tasks required under this alternative include monitoring and periodic reviews. It is anticipated that monitoring of residential wells for VOCs and metals to assess plume contaminant extent and migration and hydraulic head measurements to evaluate groundwater flow would be required. Institutional controls (deed restrictions and ordinances), if implemented and enforced, would prevent the use of contaminated groundwater as a potable supply.

No operation or maintenance of equipment is required under this alternative. After construction and installation, the water tank and pump would become the property of the residents. Potable water would need to be provided to all affected residences. No difficulties are anticipated with the provision of delivered water. There may be some space constraint in the installation of storage tanks in the residential properties that require bulk water. No replacement of any technical components is anticipated, unless a water storage tank is damaged. Should a water tank require replacement, the risks (through inhalation and dermal contact) are expected only in the short term since bottled water can be readily provided, thereby avoiding the ingestion exposure route. The provision of delivered potable water to the affected residences would address exposure to contaminated groundwater and would meet the remedial action objective.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 2 would not reduce the toxicity, mobility, or volume of contamination through treatment since no treatment is used to address the contaminated groundwater. The statutory preference for treatment would not be satisfied under Alternative 2 to reduce risks posed by contaminated groundwater.

Short-Term Effectiveness

Implementation of Alternative 2 is not expected to pose any significant risks to the local community, the remedial workers, or to the environment. Installation of water storage tanks and periodic replenishment of the tanks or bottled water are the only proposed near-term actions; they would generally not pose problems or difficulties. Implementing proper industrial health and safety practices during the installation of water tanks and connecting the tanks to the home plumbing systems would safeguard workers and residents. Increased vehicular traffic can be expected in the communities where periodic delivery of bottled or bulk water would occur. Workers who perform long-term groundwater monitoring would be adequately protected through proper health and safety procedures and the use of appropriate personal protective equipment (PPE).

Coordination and scheduling of water deliveries would be necessary to ensure that each affected residence receives its supplies on time. Given the number of homes affected, the logistics for deliveries could be complicated by the actual water usage rates, the frequency of deliveries, and, possibly, the availability of the home owner to receive the deliveries.

No environmental impacts are anticipated under Alternative 2 since remedial activities are only conducted at residential properties.

Alternative 2 could be fully implemented approximately 6 months after the Record of Decision (ROD) has been signed and approval is issued by EPA to provide alternate water supplies. Bottled water could be provided very rapidly while the purchase and installation of water supply tanks are ongoing. Alternative 2 could achieve the RAO for protection of human health by preventing exposure to groundwater contaminants in approximately 6 months.

Implementability

Alternative 2 is readily implementable. No anticipated difficulties or uncertainties exist in providing bottled water to affected residences because there will not be any additional actions required. The provision of bulk water may provide some slight difficulty since the affected residences would need to have water storage tanks (1,000 gallons total capacity) installed and some minor modifications made to their pumping and plumbing systems; however, no major obstacles are anticipated. Severe weather, particularly snow or ice storms, could affect the timeliness of some water deliveries in the hilly terrain of the area.

Provision of bottled and bulk water is generally reliable. A limited number of vendors, however, are currently available to provide water in either form. No major technical difficulties are anticipated in providing bottled water. For bulk water storage, finding a bulk water provider and the availability of space for the storage tank(s) at a residence may be issues. Each home will need to be assessed on how and where the storage tanks could be integrated into the existing plumbing system.

The anticipated future remedial actions needed include providing more residences with either bottled or bulk water should currently uncontaminated wells become affected by groundwater contamination. Another possibility is that homes that would be provided with bottled water under this alternative would have higher contamination levels as the result of plume migration; these homes would then need to be provided with bulk water storage and deliveries. Additional homes affected by contaminated water supplies can be readily provided with delivered water since no extensive remedial or construction activities would be required and vendors and equipment are readily available.

Long-term monitoring (sampling and analyses) only requires readily available resources and would be sufficient to alert the responsible agencies of additional homes that would be at risk from groundwater contamination and migration. If the monitoring is insufficient to identify contaminant migration or extent, the residents using contaminated water could be exposed, in the short term, to contaminants that result in carcinogenic and noncarcinogenic risks comparable to those estimated under the preliminary risk assessment.

Coordination among EPA, the state, and local government would be required for the implementation of bottled and bulk water deliveries. Permits are not anticipated to be required under Alternative 2. Coordination with other agencies may be required for the ordinances to prohibit use of untreated contaminated groundwater for drinking and for the 5-year review process. Deed restrictions and ordinances may be difficult to implement and enforce.

The criterion of availability of treatment technologies, TSD facilities, and capacity is not applicable.

A number of companies are available with personnel and equipment to provide either bottled or bulk delivered water and to install and connect water storage tanks. Firms are available to perform the long-term groundwater monitoring, including sampling and analyses, and to interpret and report the results. All proposed Alternative 2 remedial actions can be competitively bid. Regulatory personnel and environmental specialists are readily available to perform effective 5-year reviews.

Cost

The cost estimates developed for the two Alternative 2 scenarios are

Alternative 2A:

Capital costs:	$120,420
Average annual O&M costs:	$314,440 (years 1 through 30)
Five-year reviews:	$23,000 per event

Over a 30-year period, the net present-worth cost of Alternative 2A is $4,071,951.

Alternative 2B

Capital costs: $22,270

Average annual O&M costs: $140,200 (years 1 through 30)

Five-year reviews: $23,000 per event

Over a 30-year period, the net present-worth cost of Alternative 2B is $1,811,645.

4.1.3 Alternative 3 - Point-of-Entry Treatment

Point-of-entry treatment units would be used in Alternative 3 to treat the groundwater at each affected residence so that the finished water would not contain contaminants in excess of MCLs and would not result in unacceptable carcinogenic and noncarcinogenic risks. The treatment systems would generally be composed of a prefilter for suspended solids removal, dual in-series activated carbon units for VOCs removal, and an ultraviolet radiation disinfection unit. Water softening units, based on each home's specific situation, may be added to remove manganese and iron that could result in fouling of the UV system or to diminish manganese concentrations that result in noncarcinogenic risks (Hazard Index greater than 1.0). The activated carbon would be replaced on a periodic basis or when breakthrough has been determined. Through the provision of these treatment systems, contaminant concentrations would be reduced to below the drinking water criteria (MCLs). Institutional controls such as ordinances or deed restrictions may be used to prohibit the use of contaminated groundwater for drinking water use at locations where treatment is not employed. Long-term monitoring would be used to determine whether the water supplies of other residences may become affected and to determine the status of groundwater contamination. Annual monitoring of groundwater for VOCs and metals would be performed to assess the status of the contaminant plume and to assess whether additional homes may be at risk from contaminated groundwater. Because contaminants remain in the aquifer and would continue to pose threats to groundwater users, 5-year reviews would be conducted to assess site conditions and whether additional response actions are necessary. The key features of Alternative 3 are identified on Figure 3-2.

Overall Protection of Human Health and the Environment

Under Alternative 3, all 29 residents who are currently exposed to contaminated groundwater in excess of MCLs (for drinking) or whose use of their private water supply would result in carcinogenic risk greater than 1E-4 would be protected through the provision of point-of-entry treatment systems. The excess risk that would result from the use of untreated contaminated groundwater would be eliminated for each exposure pathway (ingestion, inhalation, and dermal contact).

Alternative 3 could provide short-term and long-term protection for residents whose water supplies have been contaminated and could constitute a permanent solution for the contaminated water supplies. Long-term reliability of the alternative to prevent exposures is dependent on the proper operation and maintenance of the treatment systems.

Deed restrictions and local ordinances could be used to prohibit untreated contaminated water use for drinking, thereby protecting private residences who intend to use the groundwater supplies. The long-term groundwater monitoring program would alert the responsible agency of changes in groundwater contamination or whether additional residential wells are affected by groundwater contamination.

Compliance with ARARs

Alternative 3 would be consistent with the federal and state chemical-specific ARARs since the point-of-entry treatment systems would be designed to produce potable water that meets the numerical limits identified in the primary drinking water criteria (MCLs).

There are no location-specific ARARs pertinent to the implementation of Alternative 3.

Alternative 3 would comply with the action-specific requirements under Title 29 of the Code of Federal Regulations for occupational safety and health since workers who install and perform periodic maintenance of the treatment systems and workers who sample the long-term monitoring wells would conform with these requirements. The transport and disposal of spent activated carbon would be in compliance with the applicable portions of Resource Conservation and Recovery Act requirements (40 CFR Parts 262 and 263) and the applicable portions of the Hazardous Materials Transportation requirements (49 CFR 107, 171-179). All measures would be taken to safely remove and transport the spent carbon to a facility for regeneration.

Long-Term Effectiveness and Permanence

With the implementation of Alternative 3, overall carcinogenic and noncarcinogenic risks through exposures to contaminated groundwater could be expected to be reduced to within or below the EPA's acceptable risk range (1E-4 to 1E-6 and Hazard Index of 1.0, respectively). The provision of point-of-entry treatment systems would eliminate or reduce ingestion, inhalation, and dermal contact risks resulting from the use of contaminated water supplies. Long-term reliability of this alternative would be dependent on the proper operation and maintenance of the treatment units to ensure effective removal of organic and inorganic contaminants.

Contaminants that are currently present in the aquifer would have the potential to continue to migrate downgradient and contaminate other residential wells or springs, and those residents could be exposed to chemicals and metals that would result in unacceptable risks or the use of water that does not meet drinking water criteria. If contaminant concentrations in the raw water increase over time, then the treatment systems could need to be upgraded to maintain the same degree of protection. Therefore, long-term monitoring and the 5-year reviews would be required under Alternative 3 to assess whether additional residential wells are contaminated and whether additional response actions are needed to mitigate health risks.

Alternative 3 would be effective in the long term and could be implemented as either an interim or a permanent remedy to the contaminated water supplies problem. The proposed treatment system under this alternative should be capable of achieving the treatment goals (MCLs) since the individual treatment components have been demonstrated to be effective in removing the contaminants of concern. Treatment systems would need to be provided indefinitely until the contaminant source control and remedial actions have been implemented so that the groundwater quality is suitable for potable use.

Long-term operation and maintenance required under Alternative 3 would include periodic servicing of the treatment units (replacement of activated carbon, water softening agents, and UV bulbs), long-term monitoring, and the 5-year reviews. It is anticipated that residential wells would be monitored for VOCs and metals to assess plume contaminant extent and migration, and hydraulic head measurements would be used to evaluate groundwater flow. No technical difficulties are anticipated in servicing the long-term treatment systems or monitoring groundwater. Institutional controls (deed restrictions and ordinances), if implemented and enforced, would prevent the use of untreated contaminated groundwater as a potable supply. However, enforcement of the restrictions and ordinances would be required to assure the protection of public health.

Should a point-of-entry treatment system fail in a particular residence, there would probably be some short-term exposures to contaminated water supplies while the treatment system is repaired or replaced. However, bottled water could readily be provided until repairs or replacement of the treatment systems have been completed in order to prevent ingestion exposures during the short term.

The spent activated carbon and any zeolites used for softening would need to be disposed. The spent carbon can be returned for regeneration and reuse in industrial applications. The spent zeolite can be disposed as a solid waste. Disposal of these items is not expected to pose any difficulties.

Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 3 would reduce the toxicity, mobility, or volume of contamination through treatment since activated carbon and UV treatment are used to address organic and metal contaminants and microorganisms. The statutory preference for treatment would be satisfied under Alternative 3 to reduce risks posed by contaminated groundwater. An estimated 125 gallons per person per day of groundwater would be treated by the point-of-entry systems, and the overall volume of contaminated media would be reduced. The activated carbon would capture organic compounds that would subsequently be recovered or destroyed during carbon regeneration. Metals would be rendered less mobile using either a softening process or ion exchange process. Both the organics and metals treatment would be irreversible.

Both spent carbon and any zeolites (from softening) used by the point-of-entry treatment units would require disposal. The spent activated carbon would need to be collected and returned to a manufacturer for regeneration. The spent zeolite could be disposed as solid waste.

Short-Term Effectiveness

Implementation of Alternative 3 is not expected to pose any significant risks to the local community, the remedial workers installing the treatment units, or the environment. Proper industrial health and safety practices would be implemented during the installation and connection of the treatment systems with the home plumbing systems to safeguard workers and residents. Increased vehicular traffic can be expected in the communities during the initial deliveries and installation and during subsequent servicing. However, the slight increase in vehicular traffic should pose no hazards to the communities. Workers who perform long-term groundwater monitoring would be adequately protected through proper health and safety procedures and the use of appropriate personal protective equipment. No environmental impacts are anticipated since all proposed activities would be conducted at residential properties and there would be no emission or discharges resulting from treatment.

Alternative 3 could be fully implemented approximately 6 months after the ROD has been signed and approval is issued by EPA to provide alternate water supplies. Bottled water could be provided very rapidly to those ultimately receiving point-of-entry treatment systems while the purchase and installation of the treatment systems are ongoing. Alternative 3 could achieve the RAO for protection of human health by preventing exposure to groundwater contaminants in approximately 6 months.

Implementability

Alternative 3 is technically and administratively implementable. Point-of-entry treatment systems can be readily constructed since off-the-shelf components are assembled and tailored to each residence's contaminant situation. One uncertainty associated with this alternative is the large number of treatment systems needed. Some lead time may be required to order and ship all the components required for assembly into the individual systems. While the treatment systems are being ordered and installed, the affected residences would be provided with bottled water to eliminate ingestion exposures. The provision of bottled water is generally reliable, and no major technical difficulties are anticipated. A number of vendors are currently available to supply bottled water.

The installation of water treatment systems may pose some slight difficulty since the affected residences would need to make space available for the equipment and some minor modifications to their pumping and plumbing systems would be required; however, no major obstacles are anticipated.

Point-of-entry systems are reliable if properly maintained and operated; these systems have been installed in numerous homes with similar water supply contamination problems. Under Alternative 3, one potential future remedial action could be the need to address rising contaminant levels in the water supplies. This problem can be readily addressed by augmenting the existing systems with additional treatment components or by replacing components with larger ones. Another potential future remedial action may be the need to provide additional residences with the point-of-use treatment systems if their wells become contaminated. These additional steps are not anticipated to be difficult to implement since vendors and equipment are readily available.

Long-term monitoring (sampling and analyses) under Alternative 3 only requires readily available resources and would be sufficient to alert the responsible agencies of additional homes that would be at risk from groundwater contamination and migration. If the monitoring is insufficient to identify contaminant migration or extent, some residents using contaminated water could be exposed to contaminants that result in carcinogenic and noncarcinogenic risks comparable to those estimated under the preliminary risk assessment.

Coordination among EPA, the state, and local government would be required for the installation and maintenance of the point-of-entry treatment systems. Permits are not anticipated to be required under Alternative 3. Coordination with other agencies may be required for the implementation of ordinances to prohibit use of untreated contaminated groundwater for drinking and for the 5-year review process. Deed restrictions and ordinances may be difficult to implement and enforce.

Activated carbon adsorption is a well-demonstrated technology for organics removal. Metals removal through softening and filtration is also well demonstrated. Treatment systems for point-of-entry use are routinely used in residential, commercial, and industrial applications. The disposal of spent activated carbon is a long-term maintenance requirement for Alternative 3. Spent carbon would need to be collected and returned for regeneration or disposal in a secured solid waste landfill. Many activated carbon vendors are available to provide fresh carbon and regenerate the used materials.

A number of companies are available with personnel and equipment to install and service the point-of-use treatment systems. Most vendors contacted for this FFS sell and service the treatment systems but do not lease them. Since there would potentially be the need to provide up to 29 treatment units, it may be necessary to provide sufficient lead time so that all components can be manufactured and shipped to the residences for installation.

A number of firms are available to perform the long-term groundwater monitoring, including sampling and analyses, and to interpret and report the results. All proposed remedial actions under Alternative 3 can be competitively bid. Regulatory personnel and environmental specialists are readily available to perform effective 5-year reviews.

<u>Cost</u>

The cost estimates developed for the Alternative 3 scenario are

Capital costs:	$172,230
Average annual O&M costs:	$117,240 (years 1 through 30)
Five-year reviews:	$23,000 per event

Over a 30-year period, the net present-worth cost of Alternative 3 is $1,676,700.

4.1.4 Alternative 4 - Water Line

Under Alternative 4, the distribution water main from the nearby borough of Bally would be extended throughout Hereford and Washington Townships so that service lines could be provided to all residences whose water supply contaminant levels exceed MCLs or risk-based action levels. The water main extension would require excavations in or along public roadways, installation of the underground piping for the distribution main, installation of service lines to the property lines of affected residences, and connection of the service lines to the plumbing system within each household. While the water line extension is being constructed, residences with contaminated groundwater in excess of drinking water criteria (MCLs) or risk-based action levels would be provided temporarily with an alternate water supply (either bottled water or point-of-entry treatment systems).

Institutional controls would be required to prevent the installation of new private wells that do not include treatment or prevent the use of untreated groundwater from existing wells. New private residences would be given the option to either connect to the new water supply provided by Bally or to provide their own treatment for their private water supplies.

Since contaminants remain at the site and are continuing sources of VOCs to groundwater, long-term groundwater monitoring and 5-year reviews would be required.

The key features of Alternative 4 are identified on Figure 3-5.

Overall Protection of Human Health and the Environment

Under Alternative 4, all residents who are currently exposed to contaminated groundwater in excess of MCLs (for drinking) or whose use of their private water supply would result in carcinogenic risk greater than 1E-4 or noncarcinogenic risk greater than a Hazard Index of 1.0 would be protected through the provision of the new water line. All exposures (ingestion, inhalation, and dermal contact) that would result from the use of untreated contaminated groundwater would be eliminated.

Alternative 4 would provide short-term and long-term protection for residents whose water supplies are contaminated and would constitute a permanent solution for the contaminated water supplies. Alternative 4 would be reliable as long as raw water (groundwater) was adequately treated by the municipal water supplier. Alternative 4 would comply with ARARs.

Deed restrictions and local ordinances could be used to prohibit the use of untreated contaminated water for drinking to protect private residences who intend to use the groundwater supplies. The long-term groundwater monitoring program would alert the responsible agency of changes in groundwater contamination or whether additional residential wells are affected by groundwater contamination.

Compliance with ARARs

Alternative 4 would comply with federal and state chemical-specific ARARs since the water line would furnish water that has been treated by the municipal water supplier to meet the primary drinking water criteria (MCLs).

During the implementation of Alternative 4, all reasonable measures would be taken during excavation and installation of the water line to comply with the federal and state location-specific ARARs. Measures would be implemented to not disturb any wetlands or impair the flood storage capacity of floodplains. Prior to the initiation of construction, a review would be conducted to identify any endangered species or sensitive habitats that may be encroached by the installation of the water line. Should any historic or archeological artifacts or objects be encountered during construction, the appropriate federal and state agencies would be notified to coordinate measures that would preserve or mitigate adverse effects.

Alternative 4 would comply with the action-specific requirements under Title 29 of the Code of Federal Regulations for occupational safety and health since workers who install and perform periodic maintenance of the water line and workers who perform the sampling of the long-term monitoring wells would conform with these requirements. During excavation and construction, erosion control measures would be implemented, as appropriate, to minimize sediment discharges into surface water bodies. Erosion control measures include silt fences, runoff collection and sedimentation ponds, surface water diversions, stabilization of slopes, channels, and ditches, and minimization of the exposed areas for earth-moving activities.

Long-Term Effectiveness and Permanence

With the implementation of Alternative 4, overall carcinogenic and noncarcinogenic risks through exposures to contaminated groundwater would be reduced to within or below EPA's acceptable risk range (1E-4 to 1E-6, and Hazard Quotient of 1.0, respectively), and residents would not be exposed to contaminants in excess of drinking water criteria (MCLs). The provision of a water line would eliminate ingestion, inhalation, and dermal contact risks resulting from contaminated water supplies use.

Contaminants that are currently present in the aquifer would have the potential to continue to migrate downgradient and possibly contaminate other residential wells or springs, and those residents could be exposed to organic compounds and metals that would result in unacceptable risks or the use of water that does not meet drinking water criteria. Therefore, long-term monitoring and the 5-year reviews would be required to assess whether additional residential wells are contaminated and whether additional response actions are needed to mitigate health risks.

Alternative 4 would be effective in the long term and would be a permanent solution to the contaminated water supplies. A water line is effective in protecting human health from exposures as long as the raw water is adequately treated by the municipal water supplier. The proposed water line would be capable of providing water of a quality that meets drinking water criteria.

Long-term operation and maintenance required under this alternative include periodic servicing of the water lines (e.g., flushing, replacement of damaged pipes) and maintenance of the pumping station.

It is anticipated that residential wells would be monitored for VOCs and metals to assess the migration and extent of the contaminant plume. Hydraulic head measurements would be used to evaluate groundwater flow. No difficulties are anticipated in performing the operation and maintenance of the long-term water line and pumping station. It is anticipated that the pump used to transfer treated water from Bally to Hereford and Washington Townships would require periodic servicing or replacement. The water supply service would not be interrupted if a secondary pump was available as backup. Institutional controls (deed restrictions and ordinances), if implemented and enforced, would prevent the use of untreated and contaminated groundwater as a potable supply. However, enforcement of the restrictions and ordinances would be required to assure the protection of public health.

Should there be an interruption in the water supply, there would probably not be any short-term exposures since all residential plumbing systems would not be connected to their individual wells and contaminated water would not be introduced into the homes. Usually, service can be restored fairly promptly (on the order of hours). During that period, the residents could purchase bottled water for short-term use.

No residuals or untreated wastes are associated with the implementation of this alternative.

Reduction of Toxicity, Mobility, or Volume through Treatment

If Alternative 4 is implemented, there would not be any direct treatment of contaminated groundwater associated with the Crossley Farm Site. The statutory preference for treatment to reduce risks posed by contaminanted groundwater would not be satisfied under Alternative 4.

Short-Term Effectiveness

Implementation of Alternative 4 is not expected to pose any significant risks to the local community, the remedial workers, or to the environment. During implementation, affected residences would be provided with either bottled water or point-of-entry treatment systems to prevent ingestion exposures to groundwater contaminants. During construction, the delivery of pipes and the excavation and installation of the distribution main would likely cause some hindrances to local vehicular traffic and some congestion. However, the slight increase in vehicular traffic should pose no hazards to the communities. Establishment of proper construction traffic controls (i.e., flashing lights, signs, flags) would minimize the chance of accidents. Noise levels would be increased in the short term but the impact to local community would be limited to daylight hours. Proper construction and industrial safety practices would be implemented during the installation and connection of treatment systems with the home plumbing systems to safeguard workers and residents. Workers who perform long-term groundwater monitoring would be adequately protected through proper health and safety procedures and the use of appropriate personal protective equipment

Alternative 4 could be fully implemented approximately 2 to 4 years after the ROD has been signed and approval is issued by EPA to provide alternate water supplies. Alternate water supplies could be provided very rapidly while the treatment systems are being installed. Alternative 4 could achieve the RAO for protection of human health by preventing exposure to groundwater contaminants once the water line has been installed and all 29 affected residences are connected to the line.

Implementability

Alternative 4 is technically and administratively implementable. The new water line and the four booster pumping stations can be installed using standard construction techniques and equipment. One uncertainty associated with this alternative is the lead time required to order materials. Because of current manufacturing practices in some industries where inventories of materials are deliberately kept low, lead time in ordering and fabrication is a critical factor in the implementation of the remedial action and may lead to delays in the construction schedule.

The water line would provide a reliable and uncontaminated supply of water to the affected residences. Potential future remedial actions may be needed if additional private residential water supplies are identified as contaminated. These residences could be connected to the water line and could be provided bottled water in the short term while construction is ongoing. No difficulties are anticipated for additional future remedial actions.

Long-term monitoring (sampling and analyses) only requires readily available resources and would be sufficient to alert the responsible agencies of additional homes that would be at risk from groundwater contamination and migration. If the monitoring is insufficient to identify contaminant migration or extent, some residents using contaminated water could be exposed to contaminants that result in carcinogenic and noncarcinogenic risks comparable to those estimated under the preliminary risk assessment.

Coordination among EPA, the state, and local government would be required for the installation of the water line and connection to affected residences. Coordination with the borough of Bally would be required to connect the water line to the Bally Municipal Water Department's system. Permits may be required under Alternative 4 for construction, connection to the municipal system, and connection to individual residences. It is very likely that some form of a water authority or a water board would need to be established to manage and administer the distribution of water in three municipalities. Coordination with other agencies may be required for the implementation of ordinances to prohibit use of untreated contaminated groundwater for drinking and for the 5-year review process. Deed restrictions and ordinances may be difficult to implement and enforce.

The criterion of availability of treatment technologies, TSD facilities, and capacity is not applicable to this alternative.

A number of construction companies are available with personnel and equipment to install the water line, the booster pumping station, and possibly the above-ground water storage tank. All construction techniques, equipment, and materials are commonly used and widely available.

A number of firms are available to perform the long-term groundwater monitoring, including sampling and analyses, and to interpret and report the results. All proposed remedial actions under Alternative 4 can be competitively bid. Regulatory personnel and environmental specialists are readily available to perform effective 5-year reviews.

Cost

The cost estimate for implementation of Alternative 4 is

Capital costs:	\$7,324,000 (branched distribution network) \$9,887,000 (looped distribution network)
Average annual O&M costs:	\$117,240 (years 1 through 4), \$102,740 (year 5), \$88,240 (years 6 through 30)
Five-year reviews:	\$23,000 per event

Over a 30-year period, the net present-worth cost of Alternative 4 is \$8,566,383 (branched distribution network) or \$11,140,151 (looped distribution network).

5

5.0 COMPARATIVE ANALYSIS OF WATER SUPPLY ALTERNATIVES

As part of the detailed analysis, comparisons of the remedial alternatives were made to identify differences between the alternatives and how site contaminant threats are addressed. The four alternate water supplies alternatives were compared and differences were identified. In general, Alternative 1 would offer the least protection of all alternatives since no actions would be taken to reduce exposures and risks. Alternative 4 would offer the greatest long-term and permanent remedy since all affected residences would be provided with a new potable water supply that is treated to meet drinking water criteria and would reduce or eliminate all exposure risks. Table 5-1 presents the summary of the evaluations for each alternative and comparison with the other alternatives.

<u>Overall Protection of Human Health and the Environment</u>

Alternative 1 would not be protective of human health since no actions would be taken to prevent exposure to contaminants present in current private water supplies. No risk reduction is anticipated under the no-action alternative.

Alternative 2, delivered water, would offer greater protection than Alternative 1 since ingestion, inhalation, and dermal exposures to groundwater contaminants would be reduced or eliminated. Carcinogenic risks would be reduced to below 1E-4. However, delivery of either bottled or bulk water would have to continue indefinitely until either source control or aquifer mitigation is achieved and the contaminant levels in the aquifer have diminished to acceptable concentrations. Alternative 2 would not constitute a permanent solution.

Alternative 3, point-of-entry treatment, offers comparable protection to Alternative 2 since ingestion, inhalation, and dermal exposures to groundwater contaminants in excess of MCLs would be reduced or eliminated. The use of the treatment systems could constitute either an interim or a permanent solution to the contaminated water supplies problem. However, additional exposures could occur if the groundwater contaminant concentrations were to increase as the result of plume migration. The protectiveness of Alternative 3 depends largely on the proper operation and maintenance of the treatment systems to ensure effective removal of groundwater contaminants.

Alternative 4, water line, would offer comparable protection to Alternatives 2 and 3 since ingestion, inhalation, and dermal exposures to groundwater contaminants in excess of MCLs would be eliminated. A new water line would be a permanent solution to the contaminated water supplies problem. Alternative 4 would be superior to Alternatives 2 or 3 since additional exposures could not occur even if the groundwater contaminant concentrations were to increase as the result of plume migration. The

TABLE 5 - 1
COMPARATIVE ANALYSIS OF ALTERNATIVE WATER SUPPLIES ALTERNATIVES
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PA

CRITERION: OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	ALTERNATIVE 1: NO ACTION	ALTERNATIVE 2: DELIVERED WATER	ALTERNATIVE 3: POINT-OF-ENTRY TREATMENT	ALTERNATIVE 4: WATER LINE
Protection of human health Prevent exposure to contaminated groundwater in excess of drinking water criteria or risk-based limits.	No reduction in risk is anticipated. Carcinogenic risks exceeding 1E-4 would remain. Groundwater supplies would exceed MCLs.	Potential exposures would be reduced or eliminated through *provision of delivered bottled or* bulk water. Carcinogenic risks would be reduced to below 1E-4, and new potable water supplies would not exceed MCLs. Not a permanent measure.	Potential exposures would be reduced or eliminated through *provision of treatment systems,* and risk reduction would be comparable to that provided by Alternative 2. Could be used as permanent measure. Reliability of alternative to prevent exposures depends on proper operation and maintenance of treatment systems.	Potential exposures would be eliminated through provision of new *water line, and risk reduction would* be comparable to or greater than that provided by Alternative 2. Alternative 4 is a permanent measure. Alternative 4's reliability to prevent exposures would depend on effective treatment of raw water by municipal water supplier.

TABLE 5 - 1
COMPARATIVE ANALYSIS OF ALTERNATIVE WATER SUPPLIES ALTERNATIVES
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PA

CRITERION: COMPLIANCE WITH ARARs	ALTERNATIVE 1: NO ACTION	ALTERNATIVE 2: DELIVERED WATER	ALTERNATIVE 3: POINT-OF-ENTRY TREATMENT	ALTERNATIVE 4: WATER LINE
Chemical-specific ARARs	None pertinent	Would be consistent with ARAR for drinking water criteria (MCLs).	Would be consistent with ARAR for drinking water criteria (MCLs).	Would meet drinking water criteria because water would be provided by municipal water supplier.
Location-specific ARARs	None pertinent	None pertinent	None pertinent	During excavation and construction, would comply by miniminizing impacts to wetlands and flood plains and coordinating efforts to preserve or mitigate adverse impacts to historical or archeological features.
Action-specific ARARs	None pertinent	Would comply with requirements for occupational health and safety and for transport of spent carbon for regeneration.	Would comply with requirements for occupational health and safety during installation, service, and long-term monitoring.	Would comply with occupational health and safety requirements during new water line installation and would comply with state erosion control requirements.
Other Criteria and Guidance	None pertinent	None pertinent	None pertinent	None pertinent

TABLE 5 - 1
COMPARATIVE ANALYSIS OF ALTERNATIVE WATER SUPPLIES ALTERNATIVES
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PA

CRITERION: LONG-TERM EFFECTIVENESS AND PERMANENCE	ALTERNATIVE 1: NO ACTION	ALTERNATIVE 2: DELIVERED WATER	ALTERNATIVE 3: POINT-OF-ENTRY TREATMENT	ALTERNATIVE 4: WATER LINE
Magnitude of Residual Risk	Carcinogenic risks exceeding 1E-4 and noncarcinogenic risks of Hazard Indices > 1.0 would remain. Water supplies would contain contaminants exceeding MCLs.	Carcinogenic and non-carcinogenic risks would be reduced to below or within acceptable risk range (1E-4 to 1E-6, and HI of 1.0). New water supplies would not contain contaminants exceeding MCLs.	Same as Alternative 2.	Same as Alternative 2.
Adequacy and Reliability of Controls	No controls would be implemented under Alternative 1.	Alternative 2 would protect affected residents from further exposures to contaminants in their private water supplies. However, increases in groundwater contaminant levels could pose risks to bottled water users. Delivered water is only an interim measure.	Generally comparable to Alternative 2. If contaminant levels in raw water increase, then existing treatment systems may need to be upgraded to offer the same degree of protection. Alternative 3 is reliable if treatment system is properly operated and maintained. Point-of-entry treatment can be considered as either an interim or permanent measure.	Superior to Alternatives 2 and 3 since increases in groundwater contaminant concentrations would not affect protection afforded by new supply line. Alternative 4 is reliable as long as the raw water is effectively treated by the municipal system. Alternative 4 would be a permanent remedial measure.
Need for 5-Year Review	5-year reviews would be required to assess need for additional remedial actions.	5-year reviews would be required to assess whether other private supply wells are contaminated and would need additional remedial actions.	Same as Alternative 2.	Same as Alternative 2.

AR300316

TABLE 5 - 1
COMPARATIVE ANALYSIS OF ALTERNATIVE WATER SUPPLIES ALTERNATIVES
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PA

CRITERION: REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT	ALTERNATIVE 1: NO ACTION	ALTERNATIVE 2: DELIVERED WATER	ALTERNATIVE 3: POINT-OF-ENTRY TREATMENT	ALTERNATIVE 4: WATER LINE
Treatment Process Used	None used	None used	Treatment systems would actively remove organic and metal contaminants from drinking water supplies.	None used.
Amount Destroyed or Treated	None	None	Amount treated estimated at 125 gallons per person per day. VOCs captured for off-site disposal.	None.
Reduction of Toxicity, Mobility, or Volume	None	None	Volume of VOC-contaminated water would be reduced. Mobility of metals reduced through ion exchange or precipitation.	None.
Irreversible Treatment	Not applicable	Not applicable	Carbon adsorption and metals removal treatment would be irreversible.	Not applicable.
Type and Quantity of Residuals Remaining After Treatment	Not applicable	Not applicable	Spent carbon and zeolite would be generated and require disposal.	Not applicable.
Statutory Preference for Treatment	Alternative 1 would not satisfy statutory preference.	Alternative 2 would not satisfy statutory preference.	Alternative 3 would satisfy statutory preference.	Alternative 4 would not satisfy statutory preference.

CRITERION: SHORT-TERM EFFECTIVENESS	ALTERNATIVE 1: NO ACTION	ALTERNATIVE 2: DELIVERED WATER	ALTERNATIVE 3: POINT-OF-ENTRY TREATMENT	ALTERNATIVE 4: WATER LINE
Community Protection	No risks to community since no actions would be implemented.	No significant short-term risks anticipated since bottled water can be provided fairly quickly.	No significant short-term risks anticipated since bottled water would be provided to affected residents while treatment systems are being installed.	No significant short-term risks anticipated since delivered water or treatment systems would be provided to affected residents while new water line is being installed. Increased vehicular traffic and construction may pose greater risks of accidents but could be minimized through proper traffic control.
Worker Protection	No risks to workers since no remedial actions would be implemented. For long-term monitoring, proper health and safety procedures and PPE would protect monitoring well samplers.	No risks to workers anticipated for delivery of water or water tank installations. For long-term monitoring, proper health and safety procedures and PPE would protect monitoring well samplers.	No risks to workers anticipated for treatment system installations. For long-term monitoring, same as Alternative 2.	Workers would be exposed to typical construction hazards, and could be exposed to contaminated groundwater while trenching. Hazards can be minimized through implementing proper industrial safety procedures. Long-term monitoring same as Alternatives 2 and 3.
Environmental Impacts	None anticipated since no actions would be implemented.	None anticipated since all proposed actions would be implemented at the residential property.	Same as Alternative 2.	Short-term impacts during excavation and construction of water supply lines and pumping station may be possible. Engineering controls (silt control, fugitive emissions controls, etc.) could be used to mitigate or minimize effects.
Time until Remedial Action Objectives Achieved	Can be implemented immediately.	Alternative 2 can be completed within 1 to 2 months.	Alternative 3 can be completed within 1 to 3 months.	Alternative 4 is estimated to be completed within 2 to 4 years.

AR300318

TABLE 5 - 1
COMPARATIVE ANALYSIS OF ALTERNATIVE WATER SUPPLIES ALTERNATIVES
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PA
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CRITERION: SHORT-TERM EFFECTIVENESS (cont.)	ALTERNATIVE 1: NO ACTION	ALTERNATIVE 2: DELIVERED WATER	ALTERNATIVE 3: POINT-OF-ENTRY TREATMENT	ALTERNATIVE 4: WATER LINE
Ability to Construct and Operate	No construction or operation required.	No difficulties for tank installation or water deliveries anticipated. Alternative is reliable as long as vendors available to provide delivered water.	Alternative 3 is slightly more difficult to implement then Alternative 2. Would require water deliveries in near term while all treatment systems are installed.	Most difficult to implement. Lead time may be critical factor in ordering and purchasing piping and pumps. Extensive excavations and construction would be required.
Ease of Doing More Action if Needed	Additional actions can be readily implemented if required after 5-year review.	Same as Alternative 1.	Same as Alternative 1.	Probably more easily implemented since water line would already be established and could be connected to additional residences that may be affected.
Ability to Monitor Effectiveness	Long-term monitoring would help identify additional homes with contaminated water supplies and would provide assessment of groundwater contaminant status and migration.	Same as Alternative 1. Bottled water can be provided rapidly on short notice.	Same as Alternative 2. Bottled water can be provided rapidly on short notice while additional actions are planned and implemented.	Same as Alternative 3.

TABLE 5 - 1
COMPARATIVE ANALYSIS OF ALTERNATIVE WATER SUPPLIES ALTERNATIVES
FOCUSED FEASIBILITY STUDY
CROSSLEY FARM SITE, HEREFORD TOWNSHIP, BERKS COUNTY, PA
PAGE 7 OF 8

CRITERION: IMPLEMENTABILITY	ALTERNATIVE 1: NO ACTION	ALTERNATIVE 2: DELIVERED WATER	ALTERNATIVE 3: POINT-OF-ENTRY TREATMENT	ALTERNATIVE 4: WATER LINE
Ability to Obtain Approvals and Coordinate with Other Agencies	Coordination for 5-year reviews may be required and would be implementable.	Coordination between state and local agencies for water deliveries may be required. Coordination for long-term monitoring and 5-year reviews would be required. Deed restrictions may be difficult to implement.	Coordination may be required between state and local agencies for treatment system installation and service. Same as Alternative 2 for long-term monitoring. Deed restrictions may be difficult to implement.	Coordination between various agencies and local municipalities required for the administration of water distribution system including maintenance of water lines and pump, collection of fees, and service. Same as Alternative 2 for long-term monitoring. Deed restrictions may be difficult to implement.
Availability of TSD Services and Capacities	No TSD services or capacities required.	No TSD services or capacities required.	Disposal capacity for spent carbon would be required. Used carbon would probably be regenerated and reused.	None required.
Availability of Equipment, Specialists, and Materials	Companies and personnel would be available for implementation of long-term monitoring and 5-year reviews.	Companies and personnel would be available for delivering bottled or bulk water. Same as Alternative 1 for monitoring and reviews.	Companies and personnel would be available for installing and servicing treatment systems. Same as Alternative 1 for monitoring and reviews.	Companies and personnel would be available for installing water lines. Same as Alternative 1 for monitoring and reviews.
Availability of Technology	Only typical groundwater sampling equipment and analytical laboratories required for long-term monitoring. Can be competitively bid.	Bottled and bulk water suppliers are readily available. Same as Alternative 1 for monitoring and competitive bids.	Point-of-entry treatment system suppliers are readily available. Same as Alternative 1 for monitoring and competitive bids.	Only standard water supply construction methods, personnel, and equipment needed. Same as Alternative 1 for monitoring and competitive bids.

CRITERIA: COST	ALTERNATIVE 1: NO ACTION	ALTERNATIVE 2: DELIVERED WATER (c)	ALTERNATIVE 3: POINT-OF-ENTRY TREATMENT (d)	ALTERNATIVE 4: WATER LINE
Capital Cost	$0	Alternative 2A: $120,420 Alternative 2B: $22,270	$172,230	$7,324,000 (e) $9,887,000 (f)
First-Year Annual O&M Cost (a)	$44,120	Alternative 2A: $314,440 Alternative 2B: $140,200	$117,240	$117,240 (yrs. 1 - 4) $102,740 (yr. 5) $88,240 (yrs. 6 - 30)
Present-Worth Cost (b)	$597,117	Alternative 2A: $4,071,951 Alternative 2B: $1,811,645	$1,676,700	$8,566,383 (e) $11,140,151 (f)

Note: (a) Add $23,000 every 5 years for reviews.

(b) All present-worth costs are estimated using a seven percent discount rate per OSWER Directive No. 9355.3-20, June 25, 1993.

(c) Alternative 2A: Bulk water for all 29 residences.
Alternative 2B: Bulk water for five residences; bottled water for 24 residences.

(d) Alternative 3: Point-of-entry systems for all 29 residences.

(e) Branched distribution network.

(f) Looped or gridded distribution network.

AR300321

protectiveness of Alternative 4 depends largely on the proper operation and maintenance of Bally Municipal Water Department's treatment system to ensure effective removal of groundwater contaminants.

Alternatives 2, 3, and 4 would require institutional controls through deed restrictions and local ordinances that, if implemented and enforced, would prohibit the use of untreated contaminated groundwater as a drinking water supply.

Compliance with ARARs

All alternatives proposed under this FFS would comply with their respective ARARs.

Long-Term Effectiveness and Permanence

Alternative 1 would not provide any long-term protection of human health since no actions would be taken to prevent the use of untreated contaminated groundwater. Current risks would remain unmitigated and would exceed 1E-4 for a few residences and drinking water supplies would contain contaminant levels in excess of the MCLs.

In the long term, Alternative 2 would be more protective of human health than Alternative 1 by eliminating potential exposures. Provision of delivered water to affected residences would eliminate ingestion, inhalation, and dermal exposures through contaminated water use and reduce risks to within or below the acceptable risk range. However, the use of bulk water is not a permanent remedy since long-term replenishment of individual water supplies would be required. Deed restrictions and local ordinances proposed under this alternative may provide some long-term protection of human health by restricting potential groundwater use. Deed restrictions and local ordinances are typically somewhat difficult to implement and enforce and cannot ensure complete protection over the long term. Owners of properties within the zoned areas may be reluctant to attach restrictions to their land titles. If additional private water supplies become contaminated as the result of plume migration, the exposure risks would probably be comparable to those estimated for current affected residences and exceed the acceptable risk range of 1E-4.

Alternative 3 would provide levels of protectiveness in the long term comparable to Alternative 2 since the point-of-entry treatment would prevent exposures to contaminants in the private water supplies. The long-term effectiveness of deed restrictions and local ordinances under Alternative 3 would be comparable to those of Alternative 2. The residual risks under Alternative 3 are comparable to those under Alternative 2.

Alternative 4 would provide greater protectiveness in the long term than would be offered by either Alternative 2 or 3 since a new water line would prevent exposures to all contaminants in the private water supplies. Increases in the groundwater contaminant concentrations, resulting from plume migration or additional releases from the source areas, would not affect the reliability of the supply line. The long-term effectiveness of deed restrictions and local ordinances under Alternative 4 would be comparable to those of Alternatives 2 and 3. The residual risks under Alternative 4 are comparable to those under Alternative 2.

Five-year reviews would be required for Alternatives 1, 2, 3, and 4 since contaminants remain in the groundwater, which would need to be evaluated periodically to determine the need for additional actions.

Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 1 would not satisfy the statutory preference for treatment since no remedial activities would be performed.

No reduction in toxicity, mobility, or volume through treatment would be achieved under Alternative 2 since treatment is not incorporated as a necessary component of the proposed remedial action. Alternative 2 would not satisfy the statutory preference for treatment.

Alternative 3 would satisfy the statutory preference since the point-of-entry treatment would remove organic and metal contaminants from groundwater through physical separation (filtration), activated carbon adsorption, and softening. However, disposal of the activated carbon and spent zeolite (from softening) would be required.

Alternative 4 would not provide any direct treatment of contaminated groundwater associated with the Crossley Farm Site. The statutory preference for treatment to reduce risks posed by contaminated groundwater would not be satisfied under this alternative.

Short-Term Effectiveness

Because no active response actions would be implemented under Alternative 1, no additional short-term impacts would be anticipated for this option.

Implementation of Alternative 2 would not result in significant short-term impacts to the local community, the remedial workers, or the environment. Increased vehicular traffic is expected during the installation of water storage tanks in residences and during the periodic deliveries of bottled and bulk water. Under Alternative 3, short-term impacts are comparable to those for Alternative 2 during the installation of the point-of-use treatment systems and subsequent servicing visits by a contractor to rebed the activated carbon or maintain the softening and UV disinfection units. Alternative 4 would pose the most short-term impacts to the community because of the possible disruptions caused by major roadway excavation, materials deliveries, pipe installation, road bed reconstruction, and connection of service lines to individual residences. Some of the disruptions can be moderated through proper traffic control methods to minimize traffic congestion and safety concerns or by coordinating and scheduling truck and heavy equipment operations to minimize disturbances to the local communities. Alternative 4 would take the longest to implement because of the extent of construction involved.

The times until the remedial action objective is achieved vary under the different alternatives. Alternative 2 could achieve the RAO in approximately 6 months; Alternative 3 would achieve protection of human health in approximately 6 months; and Alternative 4 is anticipated to achieve the RAO in approximately 2 to 4 years.

Implementability

Since no active remediation or response activities would occur, the no-action alternative is readily implementable. Alternative 2 is the most readily implementable remedial alternative since only minor installations or water storage tanks would be required. Alternative 3 would require more effort because of the number of treatment systems to be installed. Although 15 carbon systems are presently installed and operational, it is anticipated that these systems would be removed and 29 new units installed for a variety of reasons, including the unknown condition of the present units and the difficulty in coordinating with several vendors and performing O&M with hardware from different manufacturers. The new water line, Alternative 4, would be the most difficult to implement because of the lead times required to order and receive the necessary materials and equipment and because of the much greater construction effort involved. Coordination with other agencies and municipal governments would be required under all alternatives to coordinate long-term monitoring and the 5-year review process. More coordination would be required under Alternative 4 than any other alternative because of the need to administer or manage the water distribution system that would serve three municipalities.

For all alternatives, additional actions can be easily implemented since bottled water can be provided on short notice to protect the residents' health while more long-term or permanent actions are planned and implemented. The proposed long-term monitoring would help the responsible agency assess the status of the groundwater plume and determine whether additional actions are required.

For all alternatives, regulatory and technical personnel are available to perform the 5-year reviews effectively, and companies are available to perform the long-term monitoring.

Cost

The costs associated with each of the alternate water supplies remedial options are provided in Table 5-1. Alternative 1 would cost the least to implement since there would be no active remediation and only long-term monitoring and 5-year reviews would be performed.

For the alternatives where alternate water supply is provided, Alternative 3, point-of-entry treatment systems, would cost the least to implement. Alternatives 2A and 2B, delivered water, are more expensive than Alternative 3 because of the higher annual cost to deliver bulk water to all 29 affected residences (Alternative 2A) or even just five residences (Alternative 2B) over a 30 year-period. Alternative 4 (either distribution network option) would cost the most of all the alternatives to implement because major construction efforts and activities would be required.

There are uncertainties associated with these costs developed for the FFS. The major unknown is how many additional homes could become affected by contaminated water supplies in the future and require remedial action. As has been discussed elsewhere in this report, the complete nature and extent of the contaminated groundwater plume have not been defined. The groundwater flow regime and the interactions of the plume with the groundwater in this hydrogeologically complex area are not understood. Therefore, it is possible that homes that have not currently been impacted by the site could be affected in the future. All these issues will be investigated during the ongoing remedial investigation.

A

Appendix A

TABLE 1-6
CUMULATIVE RISKS[1]
CROSSLEY FARM
BERKS COUNTY, PENNSYLVANIA

Exposure Route	Receptor	W-2	W-3	W-4	W-5	W-8	W-9	W-16	W-17
INCREMENTAL CANCER RISK									
Ingestion	Child	3.97E-5	2.77E-6	5.06E-7	2.53E-5	8.26E-5	4.79E-5	5.42E-5	3.09E-5
	Adult	6.81E-5	4.75E-6	8.68E-7	4.34E-5	1.42E-4	8.21E-5	9.29E-5	5.30E-5
Dermal Contact	Child	1.40E-6	9.47E-8	1.73E-8	8.65E-7	3.19E-6	1.82E-6	2.01E-6	1.19E-6
	Adult	3.24E-6	2.19E-7	3.99E-8	2.00E-6	7.36E-6	4.20E-6	4.64E-6	2.75E-6
Inhalation of Volatiles	Child	1.23E-5	8.77E-7	1.60E-7	8.01E-6	2.46E-5	1.44E-5	1.65E-5	9.24E-6
	Adult	1.05E-5	7.49E-7	1.37E-7	6.84E-6	2.10E-5	1.23E-5	1.41E-5	7.89E-6
Total:	**Child**	**5.34E-5**	**3.74E-6**	**6.84E-7**	**3.42E-5**	**1.10E-4**	**6.41E-5**	**7.27E-5**	**4.14E-5**
	Adult	**8.19E-5**	**5.72E-6**	**1.04E-6**	**5.22E-5**	**1.70E-4**	**9.86E-5**	**1.12E-4**	**6.37E-5**
HAZARD INDEX									
Ingestion	Child	7.13E+0	4.90E-1	8.95E-2	4.47E+0	1.38E+1	8.05E+0	9.30E+0	5.16E+0
	Adult	3.06E+0	2.10E-1	3.84E-2	1.92E+0	5.90E+0	3.45E+0	3.99E+0	2.21E+0
Dermal Contact	Child	2.35E-1	1.67E-2	3.06E-3	1.53E-1	4.78E-1	2.79E-1	3.20E-1	1.79E-1
	Adult	1.36E-1	9.66E-3	1.76E-3	8.82E-2	2.76E-1	1.61E-1	1.85E-1	1.03E-1
Inhalation of Volatiles	Child	5.86E-4	(2)	(2)	(2)	(2)	(2)	(2)	(2)
	Adult	1.25E-4	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Total:	**Child**	**7.36E+0**	**5.07E-1**	**9.26E-2**	**4.63E+0**	**1.42E+1**	**8.33E+0**	**9.63E+0**	**5.34E+0**
	Adult	**3.19E+0**	**2.20E-1**	**4.01E-2**	**2.01E+0**	**6.17E+0**	**3.61E+0**	**4.17E+0**	**2.31E+0**

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TABLE 1-6 (Continued)
CUMULATIVE RISKS[1]
CROSSLEY FARM
BERKS COUNTY, PENNSYLVANIA

Exposure Route	Receptor	W-18	W-19	W-20	W-22	W-23	W-24	W-25	W-26
INCREMENTAL CANCER RISK									
Ingestion	Child	7.63E-5	5.29E-4	1.49E-4	1.90E-4	2.95E-6	2.14E-5	6.89E-7	8.96E-7
	Adult	1.31E-4	9.06E-4	2.56E-4	3.26E-4	5.06E-6	3.68E-5	1.18E-6	1.54E-6
Dermal Contact	Child	2.87E-6	1.96E-5	5.69E-6	7.60E-6	1.01E-7	7.80E-7	7.69E-9	1.75E-8
	Adult	6.63E-6	4.53E-5	1.31E-5	1.75E-5	2.33E-7	1.78E-6	1.77E-8	4.04E-8
Inhalation of Volatiles	Child	2.31E-5	1.61E-4	4.33E-5	5.43E-5	9.34E-7	7.40E-6	9.58E-7	1.91E-7
	Adult	1.98E-5	1.37E-4	3.70E-5	4.63E-5	7.98E-7	6.31E-6	8.12E-7	1.63E-7
Total:	**Child**	**1.02E-4**	**7.10E-4**	**1.98E-4**	**2.52E-4**	**3.99E-6**	**2.96E-5**	**1.65E-6**	**1.10E-6**
	Adult	**1.57E-4**	**1.09E-3**	**3.06E-4**	**3.90E-4**	**6.09E-6**	**4.48E-5**	**2.01E-6**	**1.74E-6**
HAZARD INDEX									
Ingestion	Child	1.31E+1	9.15E+1	2.62E+1	3.02E+1	5.22E-1	3.44E+0	3.67E-2	7.78E-2
	Adult	5.60E+0	3.92E+1	1.12E+1	1.30E+1	2.24E-1	1.47E+0	1.57E-2	3.33E-2
Dermal Contact	Child	4.50E-1	3.11E+0	8.80E-1	1.06E+0	1.78E-2	1.18E-1	5.56E-4	2.32E-3
	Adult	2.60E-1	1.79E+0	7.01E+00	6.10E-1	1.03E-2	6.83E-2	3.21E-4	1.34E-3
Inhalation of Volatiles	Child	(2)	4.31E-2	9.70E-2	5.47E-3	(2)	3.18E-4	6.84E-4	6.35E-4
	Adult	(2)	9.21E-3	2.07E-2	1.17E-3	(2)	6.79E-5	1.46E-4	1.36E-4
Total:	**Child**	**1.35E+1**	**9.47E+1**	**2.71E+1**	**3.13E+1**	**5.40E-1**	**3.56E+0**	**3.79E-2**	**8.07E-2**
	Adult	**5.86E+0**	**4.10E+1**	**1.82E+1**	**1.36E+1**	**2.34E-1**	**1.54E+0**	**1.62E-2**	**3.48E-2**

TABLE 1-6 (Continued)
CUMULATIVE RISKS[1]
CROSSLEY FARM
BERKS COUNTY, PENNSYLVANIA

Exposure Route	Receptor	W-27	W-28	W-29	W-30	W-31	W-33	W-35	W-40
INCREMENTAL CANCER RISK									
Ingestion	Child	1.21E-4	8.52E-5	1.03E-3	5.45E-6	3.18E-7	1.00E-8	8.63E-7	7.40E-7
	Adult	2.08E-4	1.46E-4	1.77E-3	9.35E-6	5.45E-7	1.72E-8	1.48E-6	1.27E-6
Dermal Contact	Child	4.65E-6	2.91E-6	3.93E-5	1.86E-7	1.42E-8	1.91E-10	8.29E-9	7.11E-9
	Adult	1.07E-5	6.72E-6	9.07E-5	4.30E-7	3.29E-8	4.40E-10	1.91E-8	1.64E-8
Inhalation of Volatiles	Child	3.62E-5	2.70E-5	2.93E-4	1.73E-6	2.19E-7	7.71E-8	1.24E-7	1.06E-7
	Adult	3.09E-5	2.30E-5	2.51E-4	1.47E-6	1.88E-7	6.54E-8	1.06E-7	9.06E-8
Total:	**Child**	**1.62E-4**	**1.15E-4**	**1.36E-3**	**7.37E-6**	**5.51E-7**	**8.73E-8**	**9.95E-7**	**8.53E-7**
	Adult	**2.50E-4**	**1.76E-4**	**2.11E-3**	**1.13E-5**	**7.66E-7**	**8.30E-8**	**1.60E-6**	**1.38E-6**
HAZARD INDEX									
Ingestion	Child	2.03E+1	1.51E+1	1.33E+2	9.64E-1	(2)	1.92E-3	2.24E-2	1.92E-2
	Adult	8.70E+0	6.46E+0	5.68E+1	4.13E-1	(2)	8.22E-4	9.59E-3	8.22E-3
Dermal Contact	Child	7.05E-1	5.15E-1	4.61E+0	3.29E-2	(2)	3.64E-5	2.15E-4	1.84E-4
	Adult	4.07E-1	2.97E-1	2.65E+0	1.90E-2	(2)	2.10E-5	1.24E-4	1.06E-4
Inhalation of Volatiles	Child	(2)	(2)	8.94E-3	(2)	5.15E-2	(2)	1.03E-4	8.80E-4
	Adult	(2)	(2)	6.10E-3	(2)	1.10E-2	(2)	2.19E-4	1.88E-4
Total:	**Child**	**2.10E+1**	**1.56E+1**	**1.37E+2**	**9.97E-1**	**5.15E-2**	**1.95E-3**	**2.36E-2**	**2.02E-2**
	Adult	**9.11E+0**	**6.75E+0**	**5.95E+1**	**4.32E-1**	**1.10E-2**	**8.43E-4**	**9.93E-3**	**8.51E-3**

TABLE 1-6 (Continued)
CUMULATIVE RISKS[1]
CROSSLEY FARM
BERKS COUNTY, PENNSYLVANIA
PAGE 4 OF 5

Exposure Route	Receptor	W-41	W-42	W-52	W-53	W-54	W-58	W-59	W-61
INCREMENTAL CANCER RISK									
Ingestion	Child	2.15E-6	2.77E-6	3.25E-7	1.77E-7	3.68E-8	2.15E-5	1.10E-4	8.29E-6
	Adult	3.68E-6	4.75E-6	5.58E-7	3.04E-7	6.30E-8	3.68E-5	1.88E-4	1.42E-5
Dermal Contact	Child	5.61E-8	9.47E-8	1.11E-8	3.37E-9	6.99E-10	1.09-6	5.48E-6	3.14E-7
	Adult	1.30E-7	2.19E-7	2.57E-8	7.77E-9	1.61E-9	2.53E-6	1.27E-5	7.26E-7
Inhalation of Volatiles	Child	5.58E-7	8.77E-7	1.03E-7	1.36E-6	2.83E-7	5.13E-6	2.73E-5	2.49E-6
	Adult	4.76E-7	7.49E-7	8.79E-8	1.16E-6	2.40E-7	4.38E-6	2.33E-5	2.12E-6
Total:	**Child**	**2.76E-6**	**3.740E-6**	**4.40E-7**	**1.54E-6**	**3.20E-7**	**2.77E-5**	**1.42E-4**	**1.11E-5**
	Adult	**4.28E-6**	**5.72E-6**	**6.72E-7**	**1.47E-6**	**3.04E-7**	**4.37E-5**	**2.44E-4**	**1.71E-5**
HAZARD INDEX									
Ingestion	Child	2.74E-1	4.90E-1	5.75E-2	3.39E-2	7.03E-3	2.90E+0	1.74E+1	2.41E+0
	Adult	1.17E-1	2.10E-1	2.47E-2	1.45E-2	3.01E-3	1.24E+0	7.45E-0	1.03E+0
Dermal Contact	Child	8.91E-3	1.67E-2	1.97E-3	6.44E-4	1.34E-4	1.07E-1	5.71E-1	6.01E-2
	Adult	5.14E-3	9.66E-3	1.13E-3	3.72E-4	7.71E-5	6.19E-2	3.30E-1	2.79E-2
Inhalation of Volatiles	Child	8.31E-4	(2)	(2)	(2)	(2)	4.79E-4	(2)	(2)
	Adult	1.78E-4	(2)	(2)	(2)	(2)	1.02E-4	(2)	(2)
Total:	**Child**	**2.84E-1**	**5.07E-1**	**5.95E-3**	**3.45E-2**	**7.17E-3**	**3.01E+0**	**1.80E+1**	**2.47E+0**
	Adult	**1.23E-1**	**2.20E-1**	**2.58E-2**	**1.49E-2**	**3.09E-3**	**1.31E+0**	**7.78E+0**	**1.06E+0**

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TABLE 1-6 (Continued)
CUMULATIVE RISKS[1]
CROSSLEY FARM
BERKS COUNTY, PENNSYLVANIA

Exposure Route	Receptor	S-64	S-71	W-72	W-99	W-107	W-110	W-124	W-137
INCREMENTAL CANCER RISK									
Ingestion	Child	3.92E-5	8.55E-8	1.63E-7	1.10E-4	1.67E-8	6.58E-7	8.72E-7	4.41E-6
	Adult	6.72E-5	1.47E-7	2.79E-7	1.89E-4	2.86E-8	1.15E-6	1.50E-6	7.56E-6
Dermal Contact	Child	1.34E-6	2.74E-8	5.56E-9	6.69E-6	3.18E-10	2.25E-8	7.46E-8	1.90E-7
	Adult	3.09E-6	6.32E-8	1.28E-8	1.54E-5	7.33E-10	5.19E-8	1.72E-7	4.38E-7
Inhalation of Volatiles	Child	1.24E-5	3.75E-8	5.15E-8	2.26E-5	1.28E-7	1.25E-7	8.23E-8	1.23E-6
	Adult	1.06E-5	(2)	4.40E-8	1.93E-5	1.09E-7	1.11E-7	7.03E-8	1.05E-6
Total:	**Child**	**5.29E-5**	**1.50E-7**	**2.20E-7**	**1.40E-4**	**1.46E-7**	**8.05E-7**	**1.03E-6**	**5.83E-6**
	Adult	**8.08E-5**	**2.10E-7**	**3.36E-7**	**2.24E-4**	**1.38E-7**	**1.31E-6**	**1.74E-6**	**9.04E-6**
HAZARD INDEX									
Ingestion	Child	6.93E+0	6.39E-2	2.88E-2	1.28E+1	3.20E-3	1.42E-3	5.31E-2	7.39E+0
	Adult	2.97E+0	2.74E-2	1.23E-2	5.49E+0	1.37E-3	6.09E-4	2.27E-2	3.17E-1
Dermal Contact	Child	2.37E-1	2.05E-2	9.83E-4	5.04E-1	6.07E-5	4.85E-5	2.82E-3	2.55E-2
	Adult	1.37E-1	1.18E-2	5.67E-4	2.91E-1	3.51E-5	2.80E-7	1.63E-3	1.47E-2
Inhalation of Volatiles	Child	(2)	(2)	(2)	7.64E-2	(2)	(2)	(2)	(2)
	Adult	(2)	(2)	(2)	1.63E-2	(2)	1.25E-5	(2)	(2)
Total:	**Child**	**7.16E+0**	**8.44E-2**	**2.97-2**	**1.34E+1**	**3.26E-3**	**1.47E-3**	**5.59E-2**	**7.64E-1**
	Adult	**3.10E+0**	**3.92E-2**	**1.29E-2**	**5.80E+0**	**1.40E-3**	**6.22E-4**	**2.44E-2**	**3.31E-1**

1 Chemical-specific risks presented in Appendix B.3.
2 No RfD available for chemical and/or exposure route.

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B

Appendix B

HALLIBURTON NUS CORPORATION		COST ESTIMATE ASSUMPTIONS	
CLIENT: US EPA III	FILE NO.: 5081	BY: LC	PAGE: 1 of 1
SUBJECT: Assumptions and Basis of Costs for Alt. 1 Crossley Farm NPL Site Focused FS		REVIEWED BY: MS	12 SEP 96

[C:\ARCS3\CROS\DFFS\ASSUME\ASSUM1.v2]

Alternative 1: No Action

ASSUMPTIONS:

1. <u>Long-term annual groundwater monitoring</u>:

   From 30 existing private wells & springs, 25 monitoring wells, + 5 QC samples. Total 60 samples annually.

   Sampling and analysis for site-specific contaminants: VOCs, metals using low detection limits.

   <u>Labor:</u> 1 event/year.

   - GW sampling 4 people @ 10 hr/day @ 3 days (inc. 10% for prep./mob/demob.) ≈ 132 hr.
   - GW sampling ≈ 132 hours @ $60/hr (w/O&P) = <u>$7920</u>.
   - Proj. mgmt/coord. ≈ 50 hours/year @ $80/hr (w/O&P) = <u>$4000</u>
   - Annual: add <u>$800</u> M&IE, ODCs & supplies @ <u>$800</u>, & <u>$600</u> shipping.

   Total ≈ <u>$14120</u>

   <u>Estimated analytical costs:</u>

   - VOCs (EPA 524.2) $200/sample @ 60 samples/yr = <u>$12000</u>
   - metals @ $175/sample @ 60 samples/yr = <u>$10500</u>

   Total = <u>$22500</u>

2. Reporting of results: 100 hr/yr @ $70 = $7000, add $500 ODCs. Total = <u>$7500</u>

3. 5-year reviews at 250 LOE @ $85/hr. Approx. $1700 ODCs. Total = <u>$23,000 per event</u>

Crossley Farm NPL Site
Berks County PA
Present Worth Analysis
Alternative 1 – No Action
[C:\ARCS3\CROS\DFFS\COST\PWALT1.WK3] 18 JUN 96

PRESENT WORTH ANALYSIS					
YEAR	PRESENT WORTH FACTOR	CAPITAL COSTS ($ 000s)	O & M COSTS ($ 000s)	5-YEAR COSTS ($ 000s)	PRESENT WORTH ($ 000s)
0	1.000	0			0.00
1	0.935		44.12		41.23
2	0.873		44.12		38.54
3	0.816		44.12		36.02
4	0.763		44.12		33.66
5	0.713		44.12	23	47.86
6	0.666		44.12		29.40
7	0.623		44.12		27.48
8	0.582		44.12		25.68
9	0.544		44.12		24.00
10	0.508		44.12	23	34.12
11	0.475		44.12		20.96
12	0.444		44.12		19.59
13	0.415		44.12		18.31
14	0.388		44.12		17.11
15	0.362		44.12	23	24.33
16	0.339		44.12		14.94
17	0.317		44.12		13.97
18	0.296		44.12		13.05
19	0.277		44.12		12.20
20	0.258		44.12	23	17.35
21	0.242		44.12		10.66
22	0.226		44.12		9.96
23	0.211		44.12		9.31
24	0.197		44.12		8.70
25	0.184		44.12	23	12.37
26	0.172		44.12		7.60
27	0.161		44.12		7.10
28	0.150		44.12		6.64
29	0.141		44.12		6.20
30	0.131		44.12	23	8.82

TOTAL PRESENT WORTH = $597,117

Discount rate of 7% per OSWER Directive No. 9355.3–20, June 25, 1993

Crossley Farm NPL Site
Berks County PA
O & M Costs
Alternative 1 – No Action
[C:\ARCS3\CROS\DFFS\COST\OMALT1.WK3] 18 JUN 96

Annual Costs

ITEM	ANNUAL O & M ITEMS ($)	5-YEAR ITEMS ($)	NOTES
1. Ground & spring water monitoring	$36,620		collect 60 GW (55 + 5 QC) samples annually, plus travel, living & shipping costs
2. Reporting	$7,500		100 LOE hours for annual reports plus other direct costs
3. 5–year Site reviews		$23,000	Reviews performed for years 5, 10, 15, 20, 25, and 30

HALLIBURTON NUS CORPORATION		COST ESTIMATE ASSUMPTIONS	
CLIENT: US EPA III	FILE NO.: 5081	BY: LC	PAGE: 1 of 4
SUBJECT: Assumptions and Basis of Costs for Alt. 2 Crossley Farm NPL Site Focused FS		REVIEWED BY: MS	12 SEP 96

[C:\ARCS3\CROS\DFFS\ASSUME\ASSUMv2.2]

Alternative 2: Delivered Water

Alternative 2A: provide bulk water all 29 affected residences.
Alternative 2B: provide bulk water to 5 affected residences, and provide bottled water to remaining 24 residences.

ASSUMPTIONS:

i. Discount rate for net present worth calculation at 7% per OSWER Directive No. 9355.3-20, June 25, 1993.

ii. Cost estimating sources:

ECHOS Environmental Restoration, Unit Cost Book and Assemblies Cost Book, Delta Technologies Group, Inc. and Marshall & Swift, 1995.

Means Heavy Construction Cost Data, 9th edition, R.S. Means Company, Inc., 1995.

Means Site Work & Landscape Cost Data, 14th edition, R.S. Means Company, Inc., 1995.

Grainger General Catalog

McMaster-Carr Supply Company catalog

iii. Abbreviations: SF = square feet; CF = cubic feet; SY = square yard; CY = cubic yard; LF = linear feet; MSF = 1000 SF; LS = lump sum; MO = month; DY = day

iv. Based on Preliminary Risk Assessment and comparison with federal/state MCLs, 30 private residential water supplies were found to pose excess health risks (carc. risk > 1 E-4 and/or HQ > 1.0) or exceeded site-related contaminant levels exceeded MCLs.

- 25 out of 30 private supply wells identified where ingestion alone was the primary contributor of risk (> 1 E-4). Therefore, an alternate drinking water source (i.e. bottled water) would eliminate ingestion risks and reduce total risk to within EPA's acceptable risk range. However, W-30 is a public water supply for a privately owned trailer home park and would not be provided an alternate water supply. Therefore, only 24 residences would be addressed.

- 5 out of 30 homes identified where ingestion or dermal contact and inhalation posed carc. risk > 1 E-4 or HQ > 1.0. Therefore, bulk water would need to be provided to eliminate the ingestion, dermal, and inhalation risks.

CAPITAL COST ITEMS:

Alternative 2A: provide bulk water to 29 affected residences.

1. Engineering:

Review data, develop specifications, etc. Included as part of engineering costs, at ~10%.

2. Water consumption rate:

Estimate at max. 125 gal per capita per day. Typical family of 4 would require ~500 gal/day, or weekly rate of ~3500 gal/residence. Actual consumption rate over a week would probably be lower, estimate at 3000 gallons. Therefore between 3 to 4 deliveries per residence per week.

3. Storage tank installation:

- Install cross-liked polyethylene (PE) UV-resistant water storage tanks with up to 1100 gal. capacity.
- Install in basement, if space available, or 1 @ 1100 gal tank can be brought into basement, or install multiple smaller tanks (say 300 gal capacity each).
- Or install outdoors (may require freeze protection through burying, insulation, or even an immersion heater).
- For FFS, assume that all storage tanks installed outdoors, without need for freeze protection. Depending on actual situation in winter months, may need to retrofit for freeze protection.

- Disconnect and remove existing well pumps
- Install 4" dia sanitary well seals (GR 2P022 @ $14 on top of PE tanks)
- Setup vertical PE tanks (McM 38555K37 @ $950 + freight)
- Install new jet well pumps (since only shallow pumping required)
- Install shut-off valves and meters
- Estimate plumber & electrician labor @ 10 hours/unit @ $40/HR

4. Bulk Water Delivery:

- Option 1: 3 deliveries per week @ 1000 gal per residence. Only one vendor (Great Oak Spring Water Co. of Reading, PA) found to date who could provide bulk potable water deliveries. All other vendors only provide bulk water for swimming pools. Based on anticipated ~87000 gallons/week, Great Oaks rough estimated between $.06 to $.08/gallon delivered. However, they felt they could lower price because of bulk quantity deliver.

For FFS, assume $.05/gallon delivered as reasonable cost. Weekly cost of $150/residence; annual cost of <u>$7800</u>/residence.

- Option 2: purchase water from Bally Municiapl Water Dept. However, would require lease of tank truck and hire driver. Cost would outweigh delivered bulk water by vendor. Option 2 probably not viable.

5. Well Decommissioning

For FFS, assume that wells would be converted to monitoring wells. Include installation of flush road box and cement in place. The need to install well screens and casing to be determined on as needed basis. Assume all 30 wells would be decommissioned.

Alternative 2B: provide bulk water to 5 affected residences, and provide bottled water to remaining 24 residences.

1. Engineering:

   Review data, develop specifications, etc. Included as part of engineering costs, at ~10%.

2. Bottled water consumption rate:

   Bottled water: Estimate at 5 gallon per capita per 2 weeks for drinking and cooking only. For family of four, estimate at 40 - 50 gallons per month. Vendor quotes of between $3.75 to $4.50 per 5-gal bottle, delivered. Room temperature dispenser stand at $2.00/month, or sell at $40 (for FFS, buy stands). Est. cost per family per month = 10 bottles @ $4.50/mo = $45/mon = $540/year.

3. Bulk water: See item 2 for Alt. 2A.

4. Well decommissioning: only 5 residential wells need be removed from service.

LONG-TERM ITEMS:

1. Long-term semi-annual groundwater monitoring:

   From 30 existing private wells & springs, 25 monitoring wells, + 5 QC samples. Total 60 samples semi-annually.

   Sampling and analysis for site-specific contaminants: VOCs, metals using low detection limits.

   Labor: Per event

   - GW sampling 4 people @ 10 hr/day @ 3 days (inc. 10% for prep./mob/demob.) ≈ 132 hr.
   - GW sampling ≈ 132 hours @ $60/hr (w/O&P) = $7920.
   - Proj. mgmt/coord. ≈ 50 hours/year @ $80/hr (w/O&P) = $4000
   - Annual: add $800 M&IE, ODCs & supplies @ $800, & $600 shipping.

   Total ≈ $14120 per semi-annual event.

   Total ≈ $28240 per annual event.

Estimated analytical costs:

- VOCs (EPA 524.2) $200/sample @ 60 samples/semi-yr = $12000
- metals @ $175/sample @ 60 samples/semi-yr = $10500

Total = $22500 per semi-annual event.
Total = $45000 per annual event.

2. Reporting of results: 200 hr/yr @ $70 = $14000, add $1000 ODCs. Total = $15000

3. 5-year reviews at 250 LOE @ $85/hr. Approx. $1700 ODCs. Total = $23,000 per event

Crossley Farm NPL Site
Berks County PA
Present Worth Analysis
Alternative 2A – Delivered Water; Bulk water for 29 residences
[C:\ARCS3\CROS\DFFS\COST\PWALT2A2.WK3] 12 SEP 96

PRESENT WORTH ANALYSIS					
YEAR	PRESENT WORTH FACTOR	CAPITAL COSTS ($ 000s)	O & M COSTS ($ 000s)	5–YEAR COSTS ($ 000s)	PRESENT WORTH ($ 000s)
0	1.000	120.42	0		120.42
1	0.935		314.44		293.87
2	0.873		314.44		274.64
3	0.816		314.44		256.68
4	0.763		314.44		239.88
5	0.713		314.44	23	240.59
6	0.666		314.44		209.52
7	0.623		314.44		195.82
8	0.582		314.44		183.01
9	0.544		314.44		171.03
10	0.508		314.44	23	171.54
11	0.475		314.44		149.39
12	0.444		314.44		139.62
13	0.415		314.44		130.48
14	0.388		314.44		121.95
15	0.362		314.44	23	122.30
16	0.339		314.44		106.51
17	0.317		314.44		99.54
18	0.296		314.44		93.03
19	0.277		314.44		86.95
20	0.258		314.44	23	87.20
21	0.242		314.44		75.94
22	0.226		314.44		70.97
23	0.211		314.44		66.33
24	0.197		314.44		61.99
25	0.184		314.44	23	62.17
26	0.172		314.44		54.15
27	0.161		314.44		50.60
28	0.150		314.44		47.29
29	0.141		314.44		44.20
30	0.131		314.44	23	44.33

TOTAL PRESENT WORTH = $4,071,951

Discount rate of 7% per OSWER DirectiveNo. 9355.3–20, July 1993

CROSSLEY FARM NPL SITE, BERKS COUNTY, PA
ALTERNATIVE 2A: DELIVERED WATER – BULK WATER to 29 RESIDENCES
W. A. NO. 37-56-3LS2; HNUS JOB NO. 5081
[C:\ARCS3\CROS\DFFS\COST\ALT2Av2.WK3] 12 SEP 96
Sheet 1

Item	Qty	Unit	Unit Cost ($) Sub.	Unit Cost ($) Mat.	Unit Cost ($) Labor	Unit Cost ($) Equip.	Total Cost ($) Sub.	Total Cost ($) Mat.	Total Cost ($) Labor	Total Cost ($) Equip.	Total Direct Cost ($)	Comments
Bulk Water Capital Costs												
1) HDPE tanks (inc. delivery)	29	EA	0.00	1,100.00	0.00	0.00	0	31,900	0	0	31,900	Catalog
2) Installation	29	EA	400.00	0.00	0.00	0.00	11,600	0	0	0	11,600	Estimated
3) Shutoff valves	29	EA	0.00	30.00	0.00	0.00	0	870	0	0	870	Catalog
4) Totalizing meters	29	EA	0.00	30.00	0.00	0.00	0	870	0	0	870	Catalog
5) Well seal	29	EA	0.00	14.00	0.00	0.00	0	406	0	0	406	Catalog
6) Convert to monitoring well (flush road box)	29	EA	0.00	150.00	200.00	0.00	0	4,350	5,800	0	10,150	Estimated
7) Jet pumps (w/shipping & install)	29	EA	0.00	500.00	100.00	0.00	0	14,500	2,900	0	17,400	Estimated
SUM OF DIRECT COSTS							11,600	52,896	8,700	0	73,196	
Direct Cost Adjustment Factors												
Safety Level D Multiplier (5% of labor and equipment)							0	0	0	0	0	
Safety Level C Multiplier (25% of labor and equipment, as listed)							0	0	0	0	0	
Site & Industrial Health & Safety Monitoring (3% of labor and equipment)							0	0	261	0	261	
Subtotal Direct Costs							11,600	52,896	8,700	0	73,457	
Engineering @ 10% of Direct Costs											7,346	
Indirect Cost Adjustment Factors												
Labor Overhead @ 120% (for field mgmt. & home office, only)							0	0	0	0	0	
Field Construction Labor Overhead @ 60%							0	0	5,220	0	5,220	
Subcontract Overhead @ 5%							580	0	0	0	580	
Tax on Subcontracts & Materials @ 5%							580	2,645	0	0	3,225	
G & A @ 10% (on labor, equip., & matl's.)							0	5,290	870	0	6,160	
Subtotal Direct and Indirect Costs							12,760	60,830	14,790	0	95,987	
Cost Adjustment Factors												
1995 to 1996 Cost Correction Factor @ 4%							510	2,433	592	0	3,535	
Adjusted Direct and Indirect Costs							13,270	63,264	15,382	0	99,522	
Prime Contractor Fee @ 10% of Total Adjusted Cost											9,952	
Total Costs											109,475	
Contingency @ 10% of Total Cost											10,947	
TOTAL ESTIMATED COST											**120,422**	

References used for cost estimates:

1) Historical data based on competitive bids submitted by subcontractors at this or other sites.
2) McMaster-Carr and Grainger catalogs.

Crossley Farm NPL Site
Berks County PA
O & M Costs
Alternative 2 – Delivered Water; Scenario A: Bulk for all 29 residences.
[C:\ARCS3\CROS\DFFS\COST\OMALT2A2.WK3] 12 SEP 96

Annual Costs

ITEM	ANNUAL O & M ITEMS ($)	5–YEAR ITEMS ($)	NOTES
1. Ground & spring water monitoring	$73,240		collect 60 GW (55 + 5 QC) samples semi–annually, plus travel, living and shipping costs
2. Reporting	$15,000		200 LOE hours for annual reports plus other direct costs
3. Bulk potable water	$226,200		Bulk water deliveries for 29 residences 3 times per week
4. 5–year Site reviews		$23,000	Reviews performed for years 5, 10, 15, 20, 25, and 30

Crossley Farm NPL Site
Berks County PA
Present Worth Analysis
Alternative 2B -- Delivered Water; Bulk water for 5 residences and bottled water for 24 residence
[C:\ARCS3\CROS\DFFS\COST\PWALT2B2.WK3] 12 SEP 96

PRESENT WORTH ANALYSIS					
YEAR	PRESENT WORTH FACTOR	CAPITAL COSTS ($ 000s)	O & M COSTS ($ 000s)	5-YEAR COSTS ($ 000s)	PRESENT WORTH ($ 000s)
0	1.000	22.27	0		22.27
1	0.935		140.20		131.03
2	0.873		140.20		122.46
3	0.816		140.20		114.44
4	0.763		140.20		106.96
5	0.713		140.20	23	116.36
6	0.666		140.20		93.42
7	0.623		140.20		87.31
8	0.582		140.20		81.60
9	0.544		140.20		76.26
10	0.508		140.20	23	82.96
11	0.475		140.20		66.61
12	0.444		140.20		62.25
13	0.415		140.20		58.18
14	0.388		140.20		54.37
15	0.362		140.20	23	59.15
16	0.339		140.20		47.49
17	0.317		140.20		44.38
18	0.296		140.20		41.48
19	0.277		140.20		38.77
20	0.258		140.20	23	42.17
21	0.242		140.20		33.86
22	0.226		140.20		31.64
23	0.211		140.20		29.57
24	0.197		140.20		27.64
25	0.184		140.20	23	30.07
26	0.172		140.20		24.14
27	0.161		140.20		22.56
28	0.150		140.20		21.09
29	0.141		140.20		19.71
30	0.131		140.20	23	21.44

TOTAL PRESENT WORTH = $1,811,645

Discount rate of 7% per OSWER Directive No. 9355.3-20, July 1993

CROSSLEY FARM NPL SITE, BERKS COUNTY, PA
ALTERNATIVE 2B: DELIVERED WATER – BULK WATER to 5 RESIDENCES, BOTTLED WATER TO 24 RESIDENCES
W. A. NO. 37-56-3LS2; HNUS JOB NO. 5081
[C:\ARCS3\CROS\DFFS\COST\ALT2B2.WK3] 12 SEP 96
Sheet 1

Item	Qty	Unit	Unit Cost ($) Sub.	Unit Cost ($) Mat.	Unit Cost ($) Labor	Unit Cost ($) Equip.	Total Cost ($) Sub.	Total Cost ($) Mat.	Total Cost ($) Labor	Total Cost ($) Equip.	Total Direct Cost ($)	Comments
Bulk Water Capital Costs												
1) HDPE tanks (inc. delivery)	5	EA	0.00	1,100.00	0.00	0.00	0	5,500	0	0	5,500	Catalog
2) Installation	5	EA	400.00	0.00	0.00	0.00	2,000	0	0	0	2,000	Estimated
3) Shutoff valves	5	EA	0.00	30.00	0.00	0.00	0	150	0	0	150	Catalog
4) Totalizing meters	5	EA	0.00	30.00	0.00	0.00	0	150	0	0	150	Catalog
5) Well seal	5	EA	0.00	14.00	0.00	0.00	0	70	0	0	70	Catalog
6) Convert to monitoring wells (flush road box)	5	EA	0.00	150.00	200.00	0.00	0	750	1,000	0	1,750	Catalog
7) Jet pumps (w/shipping & install)	5	EA	0.00	500.00	100.00	0.00	0	2,500	500	0	3,000	Catalog
BOTTLED WATER CAPITAL COSTS												
1) Room temperature dispensing stands	24	EA	0.00	40.00	0.00	0.00	0	960	0	0	960	
SUM OF DIRECT COSTS							2,000	10,080	1,500	0	13,580	
Direct Cost Adjustment Factors												
Safety Level D Multiplier (5% of labor and equipment)							0	0	0	0	0	
Safety Level C Multiplier (25% of labor and equipment, as listed)							0	0	0	0	0	
Site & Industrial Health & Safety Monitoring (3% of labor and equipment)							0	0	45	0	45	
Subtotal Direct Costs							2,000	10,080	1,500	0	13,625	
Engineering @ 10% of Direct Costs											1,363	
Indirect Cost Adjustment Factors												
Labor Overhead @ 120% (for field mgmt. & home office, only)							0	0	0	0	0	
Field Construction Labor Overhead @ 60%							0	0	900	0	900	
Subcontract Overhead @ 5%							100	0	0	0	100	
Tax on Subcontract & Materials @ 5%							100	504	0	0	604	
G & A @ 10% (on labor, equip., & matl's.)							0	1,008	150	0	1,158	
Subtotal Direct and Indirect Costs							2,200	11,592	2,550	0	17,750	
Cost Adjustment Factors												
1995 to 1996 Cost Correction Factor @ 4%							88	464	102	0	654	
Adjusted Direct and Indirect Costs							2,288	12,056	2,652	0	18,403	
Prime Contractor Fee @ 10% of Total Adjusted Cost											1,840	
Total Costs											20,243	
Contingency @ 10% of Total Cost											2,024	
TOTAL ESTIMATED COST											22,268	

References used for cost estimates:
1) Historical data based on competitive bids submitted by subcontractors at this or other sites.
2) McMaster–Carr and Grainger catalogs.

Crossley Farm NPL Site
Berks County PA
O & M Costs
Alternative 2B – Delivered Water; Scenario B: Bulk for 5 residences, bottled for 24 residences.
[C:\ARCS3\CROS\DFFS\COST\OMALT2B2.WK3] 12 SEP 96

Annual Costs

ITEM	ANNUAL O & M ITEMS ($)	5–YEAR ITEMS ($)	NOTES
1. Ground & spring water monitoring	$73,240		collect 60 GW (55 + 5 QC) samples semi–annually, plus travel, living and shipping costs
2. Reporting	$15,000		200 LOE hours for annual reports plus other direct costs
3. Bulk potable water	$39,000		Bulk water deliveries for 5 residences
4. Bottled water	$12,960		Bottled water deliveries for 24 residence
5. 5–year Site reviews		$23,000	Reviews performed for years 5, 10, 15, 20, 25, and 30

SUBJECT: Assumptions and Basis of Costs for Alt. 3 Crossley Farm NPL Site Focused FS	REVIEWED BY: MS	12 SEP 96

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Alternative 3: Point-of-Entry Treatment - provide Point-of-Entry treatment systems to all 29 affected residences.

ASSUMPTIONS:

i. Discount rate for net present worth calculation at 7% per OSWER Directive No. 9355.3-20, June 25, 1993.

ii. Cost estimating sources:

<u>ECHOS Environmental Restoration, Unit Cost Book and Assemblies Cost Book</u>, Delta Technologies Group, Inc. and Marshall & Swift, 1995.

<u>Means Heavy Construction Cost Data</u>, 9th edition, R.S. Means Company, Inc., 1995.

<u>Means Site Work & Landscape Cost Data</u>, 14th edition, R.S. Means Company, Inc., 1995.

<u>Grainger General Catalog</u>

<u>McMaster-Carr Supply Company catalog</u>

iii. Abbreviations: SF = square feet; CF = cubic feet; SY = square yard; CY = cubic yard; LF = linear feet; MSF = 1000 SF; LS = lump sum; MO = month; DY = day

iv. Based on Preliminary Risk Assessment and comparison with federal/state MCLs, 30 private residential water supplies were found to pose excess health risks (carc. risk > 1 E-4 and/or HQ > 1.0) or exceeded site-related contaminant levels exceeded MCLs.

- 25 out of 30 private supply wells identified where ingestion alone was the primary contributor of risk (> 1 E-4). Therefore, an alternate drinking water source (i.e. bottled water) would eliminate ingestion risks and reduce total risk to within EPA's acceptable risk range. However, W-30 is a public water supply for a privately owned trailer home park and would not be provided with an alternate water supply. Therefore, only 24 residences would be addressed.

- 5 out of 30 private supply wells identified where ingestion or dermal contact <u>and</u> inhalation posed carc. risk > 1 E-4 or HQ > 1.0. Therefore, point-of-entry systems would be require to eliminate the ingestion, dermal, and inhalation risks.

CAPITAL COST ITEMS:

1. <u>Engineering:</u>

Review data, develop specifications, etc. Included as part of engineering costs, at ~10%.

2. Point-of-Entry treatment systems components:

Actual configuration for each residence should be based on location-specific results. Annual replacement of carbon to maintain effective VOCs removal; annual replacement of UV bulb for preventative maintenance. Replacement of zeolite in softener/conditioner should depend on actual data.

Based on calls to vendors, none lease these treatment units. All units are sold outright. For FFS, assume purchase of systems is the only option available.

i. Pre-filter - remove sediments, fines, etc. that may clog either the carbon filter or UV unit. Install in all 29 units.

ii. Activated carbon units - removes VOCs and solvents from raw water.

- Size carbon unit: Using trichloroethene as compound for removal and an empty bed contact time (EBCT) of 10 minutes (per EPA/625/4-89/023).

EBCT (min) = VOL (CF)/Flow (CF/min); 7.48 gal/CF;

EBCT = time for water to pass through empty column
VOL = volume of vessel absent of GAC

a. 10 min = VOL (CF)/4 gpm
VOL = 10 min x 4 gal/min x CF/7.48 gal
VOL = 5.3 CF

b. 10 min = VOL (CF)/6 gpm
VOL = 10 min x 6 gal/min x CF/7.48 gal
VOL = 8 CF

Most units recommended by vendors consist of twin 13"-dia x 54" high vessels (~4.15 CF, each). So required VOL of 5.3 - 8 CF would be accommodated. Vendors advise 2.0 CF of carbon per unit.

or 5 residences where carc. risk > 1 E-4 or HQ > 1.0, specify 3.0 CF carbon per unit; balance of dual 2.0 CF carbon units.

iii. UV disinfection unit: - provides disinfection of treated water.

Select units for ~6 gpm flow rates.

Install in all 29 units.

SUBJECT: Assumptions and Basis of Costs for Alt. 3 Crossley Farm NPL Site Focused FS	REVIEWED BY: MS	12 SEP 96

iv. pH adjustment - may be required if pH in raw water from well is less then 6.5 (follow SMCL for as guideline). Based on review of field pH measurements (per Dec 22 95 fax from K. Kilmartin), approximately 23 residences have pH levels below 6.5. For costing, include pH adjustment.

v. Mn/Fe removal unit - required for homes with high manganese levels (to reduce non-carcinogenic risks) or to remove iron and manganese to protect UV lamps. Could use zeolite softener for Mn/Fe removal. Only W-29 had elevated Mn value such that HI > 1.0. Would only address Mn in this unit.

3. Point-of-Entry System Installation

Install POE systems in-line in homes. Cost of treatment systems include installation. See individual vendor pricing sheets and summary sheet (attached to calcs). Assume that 1 chemist with portable GC would be available to field analyze treated water after system installation. Estimate chemist required over 2 week period, include Photovac rental & supplies (standards, etc.). A limited number of samples (10) would be sent to fixed lab for confirmatory analysis.

LONG-TERM ITEMS:

O&M of point-of-entry treatment systems

Annual rebedding of activated carbon; remove carbon from primary unit, existing secondary unit becomes primary, new secondary unit filled with virgin carbon (~$500/yr per unit). Disposal of spent carbon would be required either through regeneration by manufacturer or disposal in licensed landfill (costs ~$500/yr per unit).

Replacement of zeolite or NaCl for water softening unit included in above as needed.

1. Long-term semi-annual groundwater monitoring:

From 30 existing private wells & springs, 25 monitoring wells, + 5 QC samples. Total 60 samples semi-annually.

Sampling and analysis for site-specific contaminants: VOCs, metals using low detection limits.

Labor: Per event

- GW sampling 4 people @ 10 hr/day @ 3 days (inc. 10% for prep./mob/demob.) ≈ 132 hr. - GW sampling ≈ 132 hours @ $60/hr (w/O&P) = $7920.
- Proj. mgmt/coord. ≈ 50 hours/year @ $80/hr (w/O&P) = $4000
- Annual: add $800 M&IE, ODCs & supplies @ $800, & $600 shipping.

Total ≈ $14120 per semi-annual event.

Total ≈ $28240 per annual event.

Estimated analytical costs:

- VOCs (EPA 524.2) $200/sample @ 60 samples/semi-yr = $12000
- metals @ $175/sample @ 60 samples/semi-yr = $10500

Total = $22500 per semi-annual event.

Total = $45000 per annual event.

2. Reporting of results: 200 hr/yr @ $70 = $14000, add $1000 ODCs. Total = $15000

3. 5-year reviews at 250 LOE @ $85/hr. Approx. $1700 ODCs. Total = $23,000 per event

Crossley Farm NPL Site
Berks County PA
Present Worth Analysis
Alternative 3A – Point–Of–Entry systems for 29 residences
[C:\ARCS3\CROS\DFFS\COST\PWALT3A2.WK3] 12 SEP 96

PRESENT WORTH ANALYSIS					
YEAR	PRESENT WORTH FACTOR	CAPITAL COSTS ($ 000s)	O & M COSTS ($ 000s)	5–YEAR COSTS ($ 000s)	PRESENT WORTH ($ 000s)
0	1.000	172.23	0		172.23
1	0.935		117.24		109.57
2	0.873		117.24		102.40
3	0.816		117.24		95.70
4	0.763		117.24		89.44
5	0.713		117.24	23	99.99
6	0.666		117.24		78.12
7	0.623		117.24		73.01
8	0.582		117.24		68.23
9	0.544		117.24		63.77
10	0.508		117.24	23	71.29
11	0.475		117.24		55.70
12	0.444		117.24		52.06
13	0.415		117.24		48.65
14	0.388		117.24		45.47
15	0.362		117.24	23	50.83
16	0.339		117.24		39.71
17	0.317		117.24		37.12
18	0.296		117.24		34.69
19	0.277		117.24		32.42
20	0.258		117.24	23	36.24
21	0.242		117.24		28.31
22	0.226		117.24		26.46
23	0.211		117.24		24.73
24	0.197		117.24		23.11
25	0.184		117.24	23	25.84
26	0.172		117.24		20.19
27	0.161		117.24		18.87
28	0.150		117.24		17.63
29	0.141		117.24		16.48
30	0.131		117.24	23	18.42

TOTAL PRESENT WORTH = $1,676,700

Discount rate of 7% per OSWER DirectiveNo. 9355.3–20, July 1993

CROSSLEY FARM NPL SITE, BERKS COUNTY, PA
ALTERNATIVE : POINT-OF-ENTRY for 29 RESIDENCES
W. A. NO. 37-56-3LS2; HNUS JOB NO. 5081
[C:\ARCS3\CROS\DFFS\COST\ALT3Av2.WK3] 12 SEP 96

Item	Qty	Unit	Unit Cost ($) Sub.	Unit Cost ($) Mat.	Unit Cost ($) Labor	Unit Cost ($) Equip.	Total Cost ($) Sub.	Total Cost ($) Mat.	Total Cost ($) Labor	Total Cost ($) Equip.	Total Direct Cost ($)	Comments
POE System Capital Costs												
1) 5 units w/3.0 CF carbon w/prefilter & UV unit	5	EA	3,000.00	0.00	0.00	0.00	15,000	0	0	0	15,000	Catalog
2) 24 units w/2.0 CF carbon w/prefilter & UV unit	24	EA	2,500.00	0.00	0.00	0.00	60,000	0	0	0	60,000	Estimated
3) Mn removal, conditioner/softener	1	EA	1,100.00	0.00	0.00	0.00	1,100	0	0	0	1,100	Catalog
4) pH adjustment	24	EA	900.00	0.00	0.00	0.00	21,600	0	0	0	21,600	Catalog
5) meters, sampling ports, shutoff valves (per syst	29	EA	200.00	0.00	0.00	0.00	5,800	0	0	0	5,800	Catalog
6) Field chemist	2	WK	0.00	200.00	2,000.00	0.00	0	400	4,000	0	4,400	Estimated
7) portable GC rental	2	WK	1,000.00	0.00	0.00	0.00	2,000	0	0	0	2,000	Estimated
8) confirmatory VOCs analysis	10	EA	250.00	0.00	0.00	0.00	2,500	0	0	0	2,500	Estimated
SUM OF DIRECT COSTS							108,000	400	4,000	0	112,400	
Direct Cost Adjustment Factors												
Safety Level D Multiplier (5% of labor and equipment)							0	0	0	0	0	
Safety Level C Multiplier (25% of labor and equipment, as listed)							0	0	0	0	0	
Site & Industrial Health & Safety Monitoring (3% of labor and equipment)							0	0	120	0	120	
Subtotal Direct Costs							108,000	400	4,000	0	112,400	
Engineering @ 10% of Labor											11,240	
Indirect Cost Adjustment Factors												
Labor Overhead @ 120% (for field mgmt. & home office, only)							0	0	0	0	0	
Field Construction Labor Overhead @ 60%							0	0	2,400	0	2,400	
Subcontract Overhead @ 5%							5,400	0	0	0	5,400	
Tax on Subcontracts & Materials @ 5%							5,400	20	0	0	5,420	
G & A @ 10% (on labor, equip., & matl's.)							0	40	400	0	440	
Subtotal Direct and Indirect Costs							118,800	460	6,800	0	137,300	
Cost Adjustment Factors												
1995 to 1996 Cost Correction Factor @ 4%							4,752	18	272	0	5,042	
Adjusted Direct and Indirect Costs							123,552	478	7,072	0	142,342	
Prime Contractor Fee @ 10% of Total Adjusted Cost											14,234	
Total Costs											156,577	
Contingency @ 10% of Total Cost											15,658	
TOTAL ESTIMATED COST											172,234	

References used for cost estimates:

1) Historical data based on competitive bids submitted by subcontractors at this or other sites.
2) McMaster-Carr and Grainger catalogs.

Crossley Farm NPL Site
Berks County PA
O & M Costs
Alternative 3 – Point–Of–Entry systems for all 29 residences.
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Annual Costs

ITEM	ANNUAL O & M ITEMS ($)	5–YEAR ITEMS ($)	NOTES
1. Ground & spring water monitoring	$73,240		collect 60 GW (55 + 5 QC) samples semi–annually, plus travel, living and shipping costs
2. Reporting	$15,000		200 LOE hours for annual reports plus other direct costs
3. Annual maint. of systems and spent carbon disposal	$29,000		29 units serviced & spent carbon disposal @ ~$1000
4. 5–year Site reviews		$23,000	Reviews performed for years 5, 10, 15, 20, 25, and 30

HALLIBURTON NUS CORPORATION		COST ESTIMATE ASSUMPTIONS	
CLIENT: US EPA III	FILE NO.: 5081	BY: LC	PAGE: 1 of 8

SUBJECT: Assumptions and Basis of Costs for Alt. 4 Crossley Farm NPL Site Focused FS	REVIEWED BY: MES	13 DEC 96

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Alternative 4: Water Line

Provide new water line from Bally Borough to 29 affected residences. Will probably need to accommodate additional residences in area that may be affected. Assume up to 200 residences total may be affected in areas adjacent to and downgradient of the Crossley Farm disposal site.

ASSUMPTIONS:

i. Discount rate for net present worth calculation at 7% per OSWER Directive No. 9355.3-20, June 25, 1993.

ii. Cost estimating sources:

   ECHOS Environmental Restoration, Unit Cost Book and Assemblies Cost Book, Delta Technologies Group, Inc. and Marshall & Swift, 1995.

   Means Heavy Construction Cost Data, 9th edition, R.S. Means Company, Inc., 1995.

   Means Site Work & Landscape Cost Data, 14th edition, R.S. Means Company, Inc., 1995.

   Grainger General Catalog

   McMaster-Carr Supply Company catalog

iii. Abbreviations: SF = square feet; CF = cubic feet; SY = square yard; CY = cubic yard; LF = linear feet; MSF = 1000 SF; LS = lump sum; MO = month; DY = day

iv. Based on Preliminary Risk Assessment and comparison with federal/state MCLs, 30 private residential water supplies were found to pose excess health risks (carc. risk > 1 E-4 and/or HQ > 1.0) or exceeded site-related contaminant levels exceeded MCLs.

   - 25 out of 30 private water wells were identified where ingestion alone was the primary contributor of risk (> 1 E-4). Therefore, a water line would eliminate all exposures and would reduce total risk to below EPA's acceptable risk range. However, W-30 is a public water supply for a privately owned trailer home park and would not be provided with an alternate water supply. Therefore, only 24 residences would be addressed.

   - 5 out of 30 homes private supply wells were identified where ingestion or dermal contact and inhalation posed carc. risk > 1 E-4 or HQ > 1.0. Therefore, the water line would eliminate the ingestion, dermal, and inhalation risks, and would reduce total risk to below EPA's acceptable risk range.

v. References

- Hammer, Mark J. Water and Waste-water Technology, John Wiley & Sons, 1975
- Viessman, Warren, Jr. & Mark J. Hammer. Water Pollution Supply and Control, 5th ed., Harper Collins College Publishers, 1993
- Brater, E.F. & H.W. King. Handbook of Hydraulics, 6th ed., McGraw Hill Book Company, 1982.
- Merritt, Frederick S., editor. Standard Handbook for Civil Engineers, 3rd ed., McGraw Hill Book Company, 1983.
- McGhee, Terrence. Water Supply and Sewerage, 6th edition. McGraw Hill Book Company, 1991.

CAPITAL COST ITEMS:

Note: Estimates of pipe and pump sizing are only approximate. For actual design, will need to establish: actual demand (water usage); estimate more accurately the topographic changes, friction losses, etc.; select type of piping network (branch vs. grid), determine fire protection need, future growth of area or expansion of service, number of appturences, etc.

1. Engineering:

Review data, develop specifications, etc. Included as part of engineering costs, at ~10% of total direct costs.

2. Pipe Sizing

- Based on USGS quad. topographic maps and location of affected wells, approximately 49,000 LF of pipe would be required for the distribution mains to reach all currently affected residences.
- Estimate ~100 LF of pipe needed from distribution main to edge of property, or 2900 LF total.
- Select cement-lined ductile iron pipe to prevent formation of iron tubercles, per recommendations from several reference texts.
- While 29 residences are affected, it may be likely that contaminated groundwater would continue to spread and affect other private wells. Assuming that up to 200 residences in Hereford and Washington Townships may eventually need to be on public water. Use average consumption rate of 125 gallons per capita per day (gpcd) or 500 gpd for each residence. Total average water demand of 100000 gpd (or 1.16 gal/sec).
- use max. usage rate = 2000 gpd/unit or 400000 gpd (Viesmann & Hammer, Fig. 4.4)
- use peak usage rate = 550 gpm = 792000 gpd (Viesmann & Hammer, Fig. 4.3)
- Elevation rise from Bally (480 ft MSL) to Huffs Church Road (860 ft MSL) of 380 ft.

- per Viessman & Hammer, use suggested water velocity = 4-6 ft/sec, and working pressure of 40-50 psig (or 92 - 115 ft of hydraulic head) for residential applications. Main distribution lines should maintain pressure of 40-75 psig.
- For FFS, will need to use branched network for piping because of the distribution of affected homes, the distances between Bally and the users, and the steep terrain. It would be more desirable to use grid piping networks for more reliability since each residence would be supplied with water from 2 directions. However, extra main distribution piping would need to be installed, more excavation and installation costs involved, etc. May not be cost effective. For FFS select branched system.

- Assume no tank storage of water for distribution system. If storage tank is desired, then will need to acquire land and install an elevated tank. Probably add at least $200,000 to direct capital costs.

i. Estimate distribution main pipe size

Use design velocity of 4 ft/sec. Initial sizing of piping based on continuity (Q=VA).

$Q = VA$ — Q = flow; Qavg = 69 gpm, Qmax = 278 gpm, Qpeak = 550 gpm
V = velocity (4 ft/sec)
A = pipe cross-sectional area.

See spreadsheet [PIPE.WK3] for sizing pipe diameter.

Water use condition	Pipe dia. (in)
Average	2.7 (min. 3")
Max.	5.3 (min 6")
Peak	7.5 (min 8")

ii. Estimate head loss due to pipe friction

Evaluate 6" or 8" lined pipe, and compare max. and peak hourly flow rates.
See spreadsheet [PIPE.WK3] for head loss (h_f) due to pipe friction, using Darcy Weissbach eqn.

D (dia) in.	Q (flow) (gpm)	f (friction factor)	L (ft)	V (ft/sec)	h_f (ft)
6	278	.022	52000	4	620.12
6	550	.022	52000	6.24	1509.13
8	278	.024	52000	1.77	83.48
8	550	.024	52000	4	426.34

Select 8" pipe for use in conceptual design of piping network. h_f not as severe as would be if 6" pipe is used, assuming max. flow conditions (426 ft @ 8" vs. 1509 ft @ 6"). Higher friction head losses would necessitate more pumping.

Assume form losses are minimal compared to pipe friction losses.

3. Size pump

Size pump required for peak flow conditions and to overcome head loss. Use energy equation to determine head delivered by lift pump.

Assumptions:
- P1 = 70 psig, pressure at Bally Borough
- Z1 = 480 ft, elev. at Bally
- V1 = assume same as V2
- P2 = 40 psig, *service pressure at Huffs Church Road*
- Z2 = 860 ft, elev. at Huffs Church Road
- V2 = same as V1
- H_p = pumping head
- h_f = 426 ft friction head loss, under peak flow
- Hv = 100 ft head loss due to valves, gates etc.
- w = 62.4 lb/cf, unit weight of water
- pump efficiency = 0.8

Use Bernoulli's eqn. (energy):

$$Z1 + P1/w + (V1^2)/2g + Hp = Z2 + P2/w + (V2^2)/2g + Hv + h_f$$

$$\begin{aligned} Hp &= (Z1\text{-}Z2) + (P1\text{-}P2)/w + Hv + h_f \\ &= (860 - 480)\text{ft} + [(70\text{-}40)/62.4]\,[144 \text{ sq in/sq ft}] + 100 + 426 \\ &= 380 \text{ ft} + 69 \text{ ft} + 526 = \underline{795 \text{ ft}} \end{aligned}$$

Select lift pumps to provide at least 1000 ft of head (for other head losses including form losses). Estimate power as:

$$HP = QwTDH/550$$

HP = theoretical horsepower
Q = 550 gpm = 1.23 cfs, discharge at peak conditions
w = 62.4 lb/cf, unit weight of water
TDH = 1000 ft, total discharge head
550 = conversion from ft-lb/sec to horsepower

$$HP = (1.23)(62.4)(1000)/550$$
$$= \underline{140 \text{ horsepowers}}$$

Actual power = 140/0.8 = 175 hp

For FFS, use 4 centrifugal lift pumps, each at 550 gpm @ 250 TDH, to deliver water. Establish lift stations every 10000 ft of pipe. Have additional 4 lift pumps on standby.

4. Lift stations

Pre-fab. sheet metal housing, anchored to poured slab. Will require electrical hook-ups to provide 3-phase, 230/460 volts service. Will require gauges and meters, connection to piping, etc.

5. Piping installation & road excavations

- All piping would need to be installed under the roadways, since there is insufficient room on the right-of-ways (non-existent at a number of locations). Assume that one lane would be excavated to install the distribution main so as not to impede local traffic significantly.

- Piping to be installed at least 3 ft below grade for freeze protection. Trenching would be required. Excavate to 4 ft, 3 ft wide, install bedding (sand, etc.), lay pipe, backfill, and lightly tamp. Resurface roadway.

- While fire service not required, based on discussions with municipalities. Install 50 fire hydrants to provide discharge points so that water line can be flushed as part of long-term maintenance (i.e., bleed air from high points, remove stagnant water, flush out rust and sediments at low points, etc.)

- Provide for traffic control (flagmen) during trenching, pipe laying, backfilling, and road way resurfacing. Assume 2 flagmen needed during construction given the sinuous nature of the roadways and poor visibility.

6. Testing of newly constructed piping

Per recommendations by McGhee (1991), filling pipe test sections (~1000 FT) with water to ensure no trapped air, applying a sustained pressure of 50 percent above the design operating pressure for at least 30 minutes, and checking to verify that leakage does not exceed AWWA specification. Estimate 2 people @ 3 HR each @ $20/HR per 1000 LF section.

7. Initial cleaning and disinfection of laid pipe

Initial cleaning of new water mains with a rigid "pig" will be necessary because of contamination by dirt, tools, and solid materials of the pipes during transport and installation. The lines would then be flushed to remove sediment and fines. After cleaning, the lines would be filled with water containing free chlorine residual of at least 1 mg/L; a free chlorine residual of at least 0.5 mg/L after 24 hour contact will be required. A total bacterial count not to exceed 500/mL and no coliform bacteria is also required. If either requirement is not met, then line would be filled with water containing 50 mg/L available chlorine that does not fall below 25 mg/L after 24 hours.

Assume 2 people @ 9 HR @ $20/HR per 1000 LF, add sampling and lab. analysis, supplies, and equipment.

8. Service connections

Connect 29 residences to distribution main for water service. Excavate trench, drill and tap, install corporation stop valve, saddle, curb box, copper tubing, backfill, compact.

Install water meter and pressure regulator at house, and connect to home system.

9. Interim water supplies

Assume that between 1 - 2 years needed to complete all administrative requirements. Estimate design and construction would occur over 1.5 to 2 year period, including low productivity or halt of construction during winter conditions.

Therefore, between ROD signing and completion of construction, Provide point-of-entry treatment systems for 29 residences (w/Mn removal for W-29) required for up to 4 year duration.

Use data from Alternative 3 to estimate cost and consumption for POE.

10. Well Decommissioning

For FFS, assume that wells would be converted to monitoring wells. Include installation of flush road box and cement in place. Installation of well screens and casing to be determined on as needed basis. Assume all 29 wells would be decommissioned.

LONG-TERM O&M:

1. O&M of water line

This will be probably be the responsibility of the new water authority, or of Bally Borough Municipal Water Dept., depending on who manages the water supply.

O&M would likely include:

- controlling the pH of the finished water to prevent pipe corrosion that could leach contaminants from the pipe into the water.
- maintaining an adequate chlorine residual to inhibit bacterial growth that could affect water quality.
- periodic cleaning to remove accumulation of rust, sediment, and bacterial growth from the lines that could degrade water quality.
- inspection, repair, or replacement of valves and hydrants.
- inspecting the lines for leakage.
- cleaning and disinfection of existing pipes after repairs or modifications.

2. O&M of point-of-entry treatment systems

See information provided in Alt. 3 for POE systems.

LONG-TERM MONITORING

Would be required even with water line in place. Will need to know extent of plume and whether additional residential wells are affected.

1. Long-term semi-annual groundwater monitoring:

From 30 existing private wells & springs, 25 monitoring wells, + 5 QC samples. Total 60 samples semi-annually.

Sampling and analysis for site-specific contaminants: VOCs, metals using low detection limits.

Labor: Per event

- GW sampling 4 people @ 10 hr/day @ 3 days (inc. 10% for prep./mob/demob.) ≈ 132 hr.
- GW sampling ≈ 132 hours @ $60/hr (w/O&P) = $7920.
- Proj. mgmt/coord. ≈ 50 hours/year @ $80/hr (w/O&P) = $4000
- Annual: add $800 M&IE, ODCs & supplies @ $800, & $600 shipping.

Total ≈ $14120 per semi-annual event.

SUBJECT: Assumptions and Basis of Costs for Alt. 4 Crossley Farm NPL Site Focused FS	REVIEWED BY: MES	13 DEC 96

Total ≈ $28240 per annual event.

Estimated analytical costs:

- VOCs (EPA 524.2) $200/sample @ 60 samples/semi-yr = $12000
- metals @ $175/sample @ 60 samples/semi-yr = $10500

Total = $22500 per semi-annual event.

Total = $45000 per annual event.

2. Reporting of results: 200 hr/yr @ $70 = $14000, add $1000 ODCs. Total = $15000

3. 5-year reviews at 250 LOE @ $85/hr. Approx. $1700 ODCs. Total = $23,000 per event

Crossley Farm NPL Site
Berks County PA
Present Worth Analysis
Alternative 4 - Water Line, branched network, with POE system for 29 residences during interim
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PRESENT WORTH ANALYSIS					
YEAR	PRESENT WORTH FACTOR	CAPITAL COSTS ($ 000s)	O & M COSTS ($ 000s)	5-YEAR COSTS ($ 000s)	PRESENT WORTH ($ 000s)
0	1.000	7,324			7,323.55
1	0.935		117.24		109.57
2	0.873		117.24		102.40
3	0.816		117.24		95.70
4	0.763		117.24		89.44
5	0.713		88.24	23	79.31
6	0.666		88.24		58.80
7	0.623		88.24		54.95
8	0.582		88.24		51.36
9	0.544		88.24		48.00
10	0.508		88.24	23	56.55
11	0.475		88.24		41.92
12	0.444		88.24		39.18
13	0.415		88.24		36.62
14	0.388		88.24		34.22
15	0.362		88.24	23	40.32
16	0.339		88.24		29.89
17	0.317		88.24		27.93
18	0.296		88.24		26.11
19	0.277		88.24		24.40
20	0.258		88.24	23	28.75
21	0.242		88.24		21.31
22	0.226		88.24		19.92
23	0.211		88.24		18.61
24	0.197		88.24		17.40
25	0.184		88.24	23	20.50
26	0.172		88.24		15.19
27	0.161		88.24		14.20
28	0.150		88.24		13.27
29	0.141		88.24		12.40
30	0.131		88.24	23	14.61

TOTAL PRESENT WORTH = $8,566,383

Discount rate of 7% per OSWER Directive No. 9355.3-20, June 25, 1993

CROSSLEY FARM NPL SITE, BERKS COUNTY, PA
ALTERNATIVE 4: WATER LINE for 29 RESIDENCES, BRANCHED NETWORK
W. A. NO. 37-56-3LS2; HNUS JOB NO. 5081
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Item	Qty	Unit	Unit Cost ($)				Total Cost ($)				Total Direct Cost ($)	Comments
			Sub.	Mat.	Labor	Equip.	Sub.	Mat.	Labor	Equip.		
WATER LINE CAPITAL COSTS												
MOBILIZATION/DEMOBILIZATION												
1) Office Trailer (2 ea)	24	MO	1,000.00	0.00	0.00	0.00	24,000	0	0	0	24,000	
2) Storage Trailer (1 ea)	24	MO	500.00	0.00	0.00	0.00	12,000	0	0	0	12,000	
3) Construction Survey	1	LS	10,000.00	0.00	0.00	0.00	10,000	0	0	0	10,000	
4) Portable Communication Equipment	4	SETS	1,500.00	0.00	0.00	0.00	6,000	0	0	0	6,000	
5) Equipment Mobilization/Demobilization	1	LS	40,000.00	0.00	0.00	0.00	40,000	0	0	0	40,000	
6) Site Utilities	24	MO	5,000.00	0.00	0.00	0.00	120,000	0	0	0	120,000	
STAGING AREA SITE PREPARATION												
1) Grubbing and clearing	1	AC	0	0	1,425	1,575	0	0	1,425	1,575	3,000	[021 104 0300]
2) Haul road construction - grading	4700	SY	0	0	0	0	0	0	752	1,269	2,021	[17 03 0103]
2a) Gravel/crushed rock	1556	CY	0.00	20.18	0.36	0.68	0	31,400	560	1,058	33,018	[17 03 0418]
24b) Grade and compact	4700	SY	0.00	0.00	0.26	0.15	0	0	1,217	696	1,913	[17 03 0510]
3) Erosion controls, silt fences	10000	LF	0.00	0.43	0.86	0.01	0	4,300	8,600	100	13,000	[18 05 0206]
4) Dust control (water tank)	1	EA	0	5,000	0	0	0	5,000	0	0	5,000	
4a) Spray from tank truck	24	MO	0.00	0	1,160	1,293	0	0	27,840	31,027	58,867	[18 05 0413]
TRENCHING												
1) Trench 3 ft W x 4 ft D; 4@ 8" cut w/backfill	51900	LF	0.00	0.00	1.20	1.20	0	0	62,280	62,280	124,560	[022 258 2600]
2) Compaction	51900	LF	0.00	0.00	0.60	0.60	0	0	31,140	31,140	62,280	[022 258 3200]
3) Bedding 1 ft granular fill @ 3 ft W	5444	CY	0.00	12.55	3.36	1.37	0	68,322	18,292	7,458	94,072	[022 010 0050]
WATER LINE INSTALLATION												
1) 8" ductile iron w/cement liner, push-on joint	51900	LF	0.00	8.70	5.35	0.91	0	451,530	277,665	47,229	776,424	[026 650 3040]
2) 8" Connectors, elbows, etc. @ 20% of piping	1	LS	0.00	0.00	0.00	0.00	0	0	0	0	155,285	
3) Gate valves w/boxes	50	EA	0.00	720.00	181.00	30.50	0	36,000	9,050	1,525	46,575	[026 400 3846]
4) Corporation stops, tap,curb box, exc./backfill	29	EA	0.00	133.00	395.00	0.00	0	3,857	11,455	0	15,312	[12.3-9254040]
5) hydrants, 10 ft offset, 4 ft deep	50	EA	0.00	2825.00	485.00	0.00	0	141,250	24,250	0	165,500	[12.3-9222700]
6) Connect supply line to home plumbing	29	EA	0.00	100.00	400.00	50.00	0	2,900	11,600	1,450	15,950	
7) Testing, cleaning, and disinfection of new lines	52	MLF	300.00	100.00	480.00	200.00	15,600	5,200	24,960	10,400	56,160	estimated
LIFT STATIONS												
1) clearing & grading for lift sta. construct.	1	LS	2000.00	0.00	0.00	0.00	2,000	0	0	0	2,000	
2) 4 concrete slabs, 16' x 22' x 8"	35	CY	0.00	8.01	3.90	12.00	0	280	137	420	837	[033 172 4650]
3) pre-engineered bldgs. 4 @ 12' x 16'	768	SF	0.00	54.00	0.00	0.00	0	41,472	0	0	41,472	[33 43 0101]
4) 4 centrifugal pumps, 4 backup	8	EA	0.00	13793.00	934.90	159.87	0	110,344	7,479	1,279	119,102	[33 29 0141]
5) tie to distribution main	8	EA	0.00	5000.00		0.00	0	40,000	0	0	40,000	
6) utilities (elec.)	4	EA	2000.00	0.00	0.00	0.00	8,000	0	0	0	8,000	
7) control panels w/wiring & controls	4	EA	0.00	5000.00	1000.00	0.00	0	20,000	4,000	0	24,000	
8) 8" piping to and from lift stations	400	LF	0.00	8.70	5.35	0.91	0	3,480	2,140	364	5,984	[026 650 3040]
9) Trench 3 ft W x 4 ft D; 4@ 8" cut w/backfill	400	LF	0.00	0.00	1.20	1.20	0	0	480	480	960	[022 258 2600]
10) Interior/exterior lighting	4	LS	2000.00	0.00	0.00	0.00	8,000	0	0	0	8,000	

CROSSLEY FARM NPL SITE, BERKS COUNTY, PA
ALTERNATIVE 4: WATER LINE for 29 RESIDENCES, BRANCHED NETWORK
W. A. NO. 37-56-3LS2; HNUS JOB NO. 5081
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Sheet 2 of 3

			Unit Cost ($)				Total Cost ($)				Total Direct Cost ($)	Comments
Item	Qty	Unit	Sub.	Mat.	Labor	Equip.	Sub.	Mat.	Labor	Equip.		
ROAD RESURFACING												
1) asphaltic concrete pavement, binder course 2"	16333	SY	0.00	3.94	0.38	0.34	0	64,353	6,207	5,553	76,113	[025 104 0160]
2) asphaltic concrete, wearing course 3"	16333	SY	0.00	4.32	0.42	0.39	0	70,560	6,860	6,370	83,790	[025 104 0460]
SITE STAFFING												
1) Site manager	24	MO	0.00	0.00	7174.00	0.00	0	0	172,176	0	172,176	Estimated
2) Site engineer	24	MO	0.00	0.00	6184.00	0.00	0	0	148,416	0	148,416	Estimated
3) Site supervisor/foreman	24	MO	0.00	0.00	4280.00	0.00	0	0	102,720	0	102,720	Estimated
4) Clerical support	24	MO	0.00	0.00	1978.00	0.00	0	0	47,472	0	47,472	Estimated
5) Flagmen (2 needed for road traffic control)	24	MO	0.00	0.00	3960.00	0.00	0	0	95,040	0	95,040	[99 01 0601]
HOME OFFICE SUPPORT STAFFING												
1) Project manager	24	MO	0.00	0.00	8000.00	0.00	0	0	192,000	0	192,000	Estimated
2) Lead engineer	24	MO	0.00	0.00	6400.00	0.00	0	0	153,600	0	153,600	Estimated
3) Contracts/subcontracting specialist	24	MO	0.00	0.00	2800.00	0.00	0	0	67,200	0	67,200	Estimated
4) Clerical & administrative support	24	MO	0.00	0.00	3164.80	0.00	0	0	75,955	0	75,955	Estimated
POE System Capital Costs (during interim)												
1) units w/3.0 CF carbon w/filter & UV unit	29	EA	3,000.00	0.00	0.00	0.00	87,000	0	0	0	87,000	Vendor quotes
2) Mn removal, conditioner/softener	1	EA	1,100.00	0.00	0.00	0.00	1,100	0	0	0	1,100	Vendor quotes
3) pH adjustment	29	EA	900.00	0.00	0.00	0.00	26,100	0	0	0	26,100	Vendor quotes
4) meters, sampling ports, shutoff valves (per sy	29	EA	200.00	0.00	0.00	0.00	5,800	0	0	0	5,800	Catalogs
5) Field chemist	3	WK	0.00	0.00	1,250.00	0.00	0	0	3,750	0	3,750	
6) portable GC rental	3	WK	1,000.00	0.00	0.00	0.00	3,000	0	0	0	3,000	
7) confirmatory VOCs analysis	29	EA	250.00	0.00	0.00	0.00	7,250	0	0	0	7,250	
Well Decommissioning												
1) decomm. 30 wells after water line installed	29	EA	0.00	150.00	200.00	0.00	0	4,350	5,800	0	10,150	
			SUM OF DIRECT COSTS				375,850	************************	211,673		3,449,925	

AR300365

CROSSLEY FARM NPL SITE, BERKS COUNTY, PA
ALTERNATIVE 4: WATER LINE for 29 RESIDENCES, BRANCHED NETWORK
W. A. NO. 37-56-3LS2; HNUS JOB NO. 5081
[C:\ARCS3\CROS\DFFS\COST3\ALT5v3.WK4] 18 DEC 96

	Total Cost ($) Sub.	Mat.	Labor	Equip.	
SUM OF DIRECT COSTS	375,850	************************		211,673	3,449,925
Direct Cost Adjustment Factors					
Safety Level D Multiplier (5% of labor, matl's. & equip.)	0	0	0	0	0
Safety Level C Multiplier (25% of labor & equipment)	0	0	0	0	0
Site & Industrial Health & Safety Monitoring (3% of labor and equipment)	0	0	48,076	6,350	54,426
Subtotal Direct Costs	375,850	************************		218,024	3,504,351
Engineering @ 10% of Direct Costs					350,435
Indirect Cost Adjustment Factors					
Labor Overhead @ 120% (for field mgmt. & home office, only)	0	0	************	0	1,265,495
Field Construction Labor Overhead @ 60%	0	0	328,763	0	328,763
Subcontract Overhead @ 5%	18,793	0	0	0	18,793
Tax on Subcontracts & Materials @ 5%	18,793	55,230	0	0	74,022
G & A @ 10% (on labor, equip., & matl's.)	0	110,460	165,059	21,802	297,322
Subtotal Direct and Indirect Costs	413,435	************************		239,826	5,839,181
Cost Adjustment Factors					
1995 to 1996 Cost Correction Factor @ 4%	16,537	50,812	136,396	9,593	213,338
Adjusted Direct and Indirect Costs	429,972	************************		249,419	6,052,519
Prime Contractor Fee @ 10% of Total Adjusted Cost					605,252
Total Costs					6,657,771
Contingency @ 10% of Total Cost					665,777
TOTAL ESTIMATED COST					**7,323,548**

Crossley Farm NPL Site
Berks County PA
O & M Costs
Alternative 4 - Water Line with temporary point-of-entry systems for 29 residences.
[C:\ARCS3\CROS\DFFS\COST3\OMALT5v3.WK4] 12 DEC 96

Annual Costs

ITEM	ANNUAL O & M ITEMS ($)	5-YEAR ITEMS ($)	NOTES
1. Ground & spring water monitoring	$73,240		collect 60 GW (55 + 5 QC) samples semi-annually, plus travel, living and shipping costs
2. Reporting	$15,000		200 LOE hours for annual reports plus other direct costs
3. Annual maint. of systems and spent carbon disposal	$29,000		29 units serviced @ ~$1000 each, and spent carbon disposal, for 4 years only
4. 5-year Site reviews		$23,000	Reviews performed for years 5, 10, 15, 20, 25, and 30